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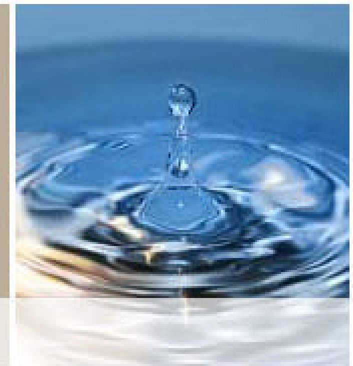

# A Study of Economic Impacts from the Implementation of a Renewable Portfolio Standard and an Energy Efficiency Program in Michigan

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# EXECUTIVE SUMMARY & KEY FINDINGS

In recent months, Michigan's policymakers and business leaders have addressed the public on the need for Michigan to gain control of its growing energy needs. Michigan currently imports 90% of its energy from out of state, at a cost exceeding $18 billion per year (projected to increase as imported energy prices rise). At the same time, these same policymakers and business leaders see an opportunity to leverage our state's entrepreneurial and manufacturing strengths by deliberately focusing them on the energy industry, with the desired outcome of generating not only more energy within Michigan, but generating more jobs for Michigan workers, and aiding Michigan's economy by reducing the amount of energy we must purchase from out of state fossil fuel and electricity supplies.

This economic impact Study deals exclusively with electricity. Many issues surface in this Study as a result of the data acquired, such as the anticipated savings that renewable energy sources can provide to Michigan as a result of reduced carbon emissions (i.e. carbon credits) should a federal carbon tax be enacted, but these assessments, while logical, are based on informed supposition rather than current data.

**The conclusions of this Study hold to the most conservative of available data.** For example, if current data suggests that wind power generation in Michigan could generate anywhere from 28% capacity to 32% capacity, this Study uses the most conservative number (28% capacity) to draw its conclusions. In this manner, all economic conclusions drawn appear as the "worst case" scenario, allowing for considerably more upsides in the actual executions of the strategies described.

A significant observation not measurable in the Study is the appeal of Michigan as a state in which out-of-state or foreign investors may seek to invest in renewable energy manufacturing. Currently, 24 states plus the District of Columbia have enacted a RPS (Renewable Portfolio Standard) into law. Their RPS laws display to the investment community a highly visible statewide commitment to renewable energy as a growth industry. **Simply put, if an investor seeks to invest in renewable energy development in a state, one of the very first things he/she looks for is whether or not the state has a RPS.** If the state has a RPS; then the state obviously is committed to the investor's industry. If the state doesn't have a RPS; then the state just as obviously is <u>not</u> committed to the investor's industry. Enacting a RPS, therefore, sends a powerful global signal and goes a long way toward securing Michigan's place on the "short list" of viable states into which investment in renewable energy manufacturing can be made.

Finally, readers should avoid the conclusion that workers speculatively hired for Michigan renewable energy generation plants in the study cases that follow are merely displaced workers shifting over from shut down fossil fuel plants. In this Study, no existing fossil fuel plants are shut down; yet new electric generation is modeled to keep pace with Michigan's energy needs. So the new jobs predicted are, in fact, new jobs.

Going forward, Michigan needs to make several important decisions on how to meet the future electric needs of its businesses and residents, for the following reasons:

- Its current electric consumption exceeds the State's generation capacity.

- The State is highly dependant on out of state electric supply through its existing transmission system, and the current level of transmission use is close to the system capacity.
- It has been 20 years since the last Michigan base load power plant was put in operation.
- Federal policies currently addressing global climate change will likely result in a mandated reduction of existing or future carbon emissions in the United States.

Although some generation capacity has been built within the last decade, most of it is natural gas fueled generation. Even with this expanded generation in place, the ability of Michigan's utilities to reliably provide electricity has become an issue of profound concern. Construction of any new base load power plants is expected to take 6-10 years, and transmission system upgrades also take upwards of ten years before any upgrade is complete. The complexity of any new nuclear power generation will require even more time than that. As it stands today, Michigan must act quickly to determine how it will meet the growing electric needs that are necessary to fuel the State's economy.

Michigan Governor Jennifer Granholm has long recognized these challenges, and on April 6, 2006 she issued Executive Directive No 2006-2, requesting that the Michigan Public Service Commission ("MPSC") develop a comprehensive and responsible electric energy plan for the State of Michigan. The 21st Century Energy Plan's ("21st CEP")[1] focus is to provide recommendations on how Michigan can reliably meet its growing electric needs and keep electric costs competitive. The 21st CEP investigates all reasonable electric supply options including the implementation of proven energy efficiency programs and the use of renewable electric generation.

**The focus of this Study is on how energy efficiency programs and Renewable Portfolio Standard (RPS) policies, both separately and combined, will affect Michigan's economy.** In addition, the modeling in this Study also provides critical information on how the implementation of energy efficiency programs and RPS policies will impact air emissions, and this report also discusses the potential economic and environmental impacts of these two policy courses with respect to a reduction in $CO_2$ emissions.

This Study uses nine different Case models, (eight hypothetical Cases and one "status quo" or Base Case model) to assess the impact on Michigan's economy of policies implemented to increase energy efficiency practices and to harness alternative forms of electric generation from renewable sources such as wind power, solar, and biomass. Initial funding was provided by the MPSC through the Low Income/Energy Efficiency (LI/EE) Program. Additional funding was provided by the Herbert H. and Grace A. Dow Foundation.

## Study Methodology

To understand how increased energy efficiency and renewable electric generation will directly affect Michigan's economy, eight hypothetical cases were developed to model alongside a "status quo/traditional utility supply" case ("Base Case"). These cases were then analyzed using two forecasting models – ENERGY 2020 (developed by Systematic Solutions, Inc) and Regional Economic Models, Inc. (REMI) Policy Insight. ENERGY 2020 modeled Michigan's electric

[1] The 21st Century Energy Plan was released on January 31, 2007 and can be viewed on the website – www.dleg.sate.mi.us/mpsc/electric/energyplan/index.htm

system consumption and supply for each case and produced projections of sources of generation, costs, emissions and electric pricing. This output from ENERGY 2020 was then sent to REMI's Policy Insight model to forecast the impacts on the State's economy resulting from each case. Results from each of the cases were then compared to the Base Case to determine the net impact of each case upon the economy of the State of Michigan.

The cases were modeled over the period of 2006 to 2025. In all Cases, 2006 was treated as a base year with all data and results containing the same values. Cases were developed to model low penetration and moderate penetration energy efficiency policy, low and moderate RPS policy, a combination of low penetration energy efficiency with low RPS policies and a combination of moderate penetration energy efficiency with moderate RPS policies. In addition, two models were included to look at the impact on Michigan's economy if Michigan were to attract new renewable energy manufacturing jobs. These two cases modified the models from the low and moderate RPS policies, to cause all manufacturing of wind generation components to be manufactured in Michigan. A brief description of each case follows:

- **Base Case**: A Michigan electric generation profile based upon historic data with future generation needs provided for in the traditional utility manner of adding a mix of new fossil fueled generation (including electricity purchased from out of state sources).

- **Low Penetration Energy Efficiency Case ("EE1")**: A profile in which Michigan implements low penetration energy efficiency programs that reduce electric consumption by an average of 443 GWh (Gigawatt hour) each year at a cost of $55.81/MWh (Megawatt hour).

- **Moderate Penetration Energy Efficiency Case ("EE2")**: A profile in which Michigan implements moderate penetration energy efficiency programs which reduce electric consumption by an average of 755 GWh each year at a cost of $27.74/MWh.[2]

- **Low RPS Case ("RPS1")**: A profile in which Michigan implements a low renewable portfolio standard (RPS) that grows to 7% of total electric sales by 2016 and remains at 7% beyond 2016.

- **Moderate RPS Case ("RPS2")**: A profile in which Michigan implements a moderate renewable portfolio standard that grows to 15% of total electric sales by 2025, and achieves an 11% RPS level in year 2020.

- **Combined Low Penetration Energy Efficiency & Low RPS Case ("EE1-RPS1")**: This case represents a combination of Case EE1 and Case RPS1.

- **Combined Moderate Penetration Energy Efficiency & Moderate RPS Case ("EE2-RPS2")**: This case represents a combination of Case EE2 and Case RPS2.

- **Low RPS Case with Michigan Manufacturing ("RPS1-Wind")**: In this case, Case RPS1 is modeled to assume that all required wind system components are produced in Michigan.

[2] This case reflects energy efficiency recommendations very similar to those found in Michigan's 21st Century Energy Plan.

- **<u>Moderate RPS Case with Michigan Manufacturing ("RPS2-Wind")</u>**: In this case, Case RPS2 is modeled to assume that all wind system components are manufactured in Michigan.

The modeling in Cases RPS1-Wind and RPS2-Wind did not include sales or service of the Michigan manufactured wind components to *any* wind energy projects outside of the State; although an economic "upside" to exporting these Michigan-made products would be likely.

The Base Case, energy efficiency, and RPS cases were developed to reflect the analysis of the various workgroups of MPSC's 21st Century Energy Plan. The following list summarizes the data assumptions that mirror those found in the 21st Century Energy Plan:

- Michigan's forecasted electric consumption
- Existing generation capability, incl. operating costs and fuel consumption
- Amount of electric generation needed and approximate timing of installation of new generation capacity
- Capital and operating cost of new fossil fuel generation capacity
- Capital and operating cost of new renewable energy generation capacity
- Cost of promotion/adoption of energy efficiency programs
- Electric consumption reductions due to energy efficiency programs

Construction of new generation was modeled to occur over a multi-year period ranging from two years for new wind generation to six years for new coal fired generation. As Michigan's electric load grows, ENERGY 2020 selects the most economical generation source to ensure sufficient generation is available to meet the load conditions. Base load coal power plants are added in the year when load growth reaches the point that utilization of the plant proves to be economical. Energy 2020 initiates plant construction prior to the year the plant is needed to serve the load.

The termination of the Study modeling at the end of 2025 impacted how new power plant construction occurs prior to 2025. If Michigan's load growth would require a new power plant in 2026, the new power plant would not be included in the modeled construction for this Study. This modeling characteristic had an adverse impact on the model results in the last five years of the Study. Therefore, toward the end of the modeling period the results were not following the trends contained in prior year results. Detailed review found the modeling was impacted by the termination of the modeling in 2025. As such, it was decided that the results to be included in this report will only be up through the end of 2020 to eliminate the end–of-period construction cycle modeling impacts. **All data used in the model will include the full modeling period of 2006 through 2025. However, results will only include the period up through the end of 2020.**

Economic outputs that are used to summarize the net impact to Michigan's economy include Gross Regional Product (GRP), Employment, and Disposable Personal Income (DPI). Outputs used to describe the net impact to air emissions include $CO_2$ emissions and fossil fuel consumption. For the purposes of this Study, the GRP figures from the modeling are actually Gross State Product (GSP).

# Key Findings

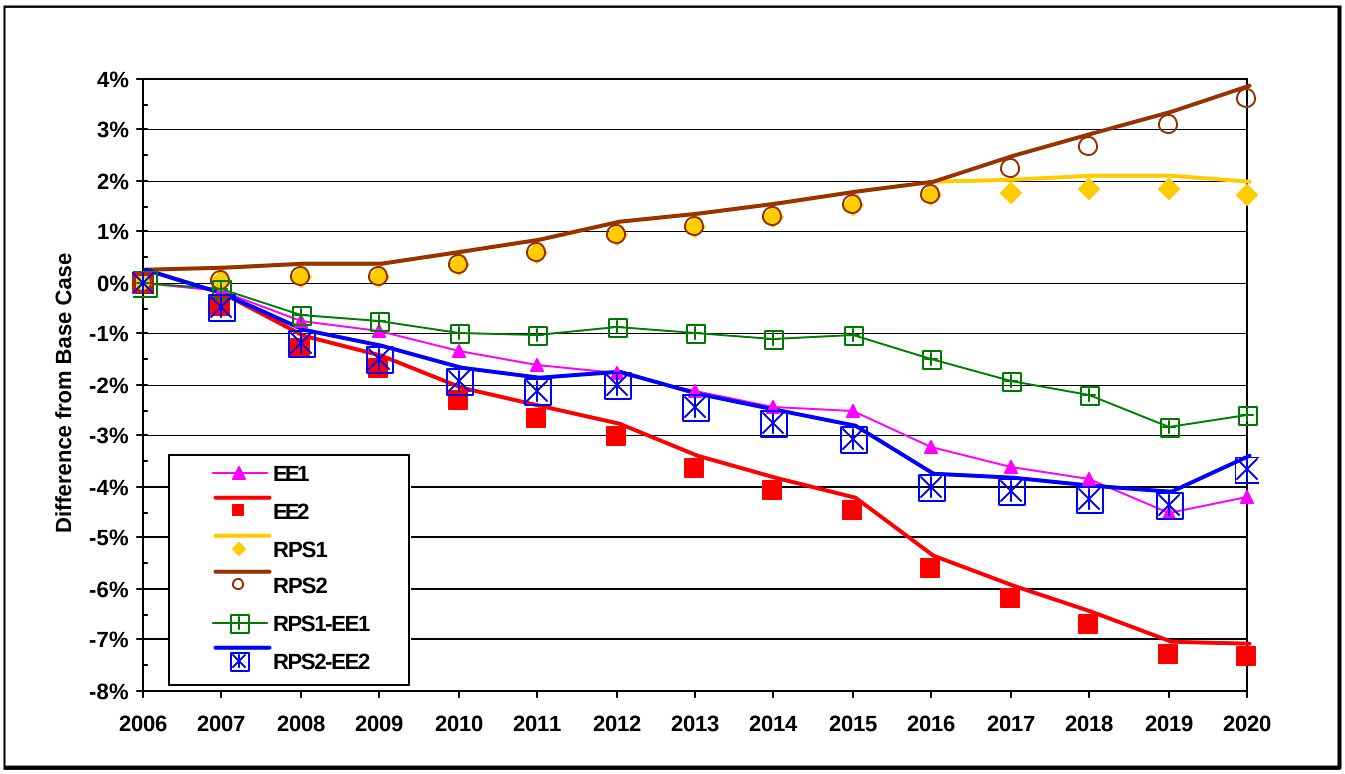
## *ENERGY EFFICIENCY PROGRAMS WILL CAUSE A SIGNIFICANTLY IMPROVEMENT IN MICHIGAN'S ECONOMY*

The Study reveals that Michigan's economy directly benefits from the implementation of energy efficiency programs:

- As seen in Figure 1, both low penetration energy efficiency (Case EE1) and moderate penetration energy efficiency (Case EE2) programs will reduce the utility electric revenues below the Base Case[3] cost level, indicating reduced electric costs for all customers. ENERGY 2020 modeling indicates that utility electric revenues reduction would exceed 7.3% with Case EE2 by 2020 (Figure 1).

- As seen in Table A, both of the energy efficiency cases (EE1 and EE2) will improve all aspects of Michigan's economy; specifically GSP, employment, and disposable personal income.

**Figure 1 - Annual Utility Revenue Difference from Base Case**




- The net present value (NPV) of GSP over the modeled period is shown by the Study to increase by $553 million (0.010%) if Case EE1 is implemented and an increase of $637 million (0.011%) if Case EE2 is implemented.

[3] The Base Case is represented in Figure 1 by the 0% line.

- Michigan's employment levels over the period of 2007-2020 are projected to increase over the Base Case by a total of 8,783 jobs (0.011%) with Case EE1 and by a total of 12,057 jobs (0.015%) with Case EE2.[4]

- With Case EE1, the NPV of disposable personal income over the period is projected to increase over the Base Case by $628 million (0.015%). With EE2, the NPV of disposable personal income is projected to increase over the Base Case by over $900 million (0.025%).

**Table A - Michigan Economic Impacts of Potential Policies (ignoring Carbon offsets)**

| | GROSS STATE PRODUCT | | | EMPLOYMENT | | | REAL DISPOSABLE PERSONAL INCOME | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2007-2020 NPV | | | 2007-2020 Total | | | 2007-2020 NPV | | |
| | Billions | Differ from Base Case ($Mil) | % Differ from Base Case | | Differ from Base Case | % Diff from Base | Billions | Differ from Base Case ($Mil) | % Differ from Base Case |
| Base Case | $5,642 | | | Base Case 2020 Emp: | 5,982 | | $4,085 | | |
| EE1 - Low Penetration Energy Efficiency Case | $5,642 | $553 | 0.010% | | 8,783 | 0.011% | $4,085 | $628 | 0.015% |
| RPS1 - Low Renewable Case | $5,642 | $194 | 0.003% | | 2,020 | 0.002% | $4,084 | ($229) | (0.006%) |
| EE1-RPS1 - Combined Low RPS & Penetration Energy Efficiency Case | $5,642 | $750 | 0.013% | | 11,204 | 0.014% | $4,085 | $415 | 0.010% |
| EE2 - Moderate Penetration Energy Efficiency Case | $5,642 | $637 | 0.011% | | 12,057 | 0.015% | $4,085 | $904 | 0.022% |
| RPS2 - Moderate Renewable Case | $5,642 | $533 | 0.009% | | 6,381 | 0.008% | $4,084 | ($100) | (0.002%) |
| EE2-RPS2 - Combined Moderate RPS & Moderate Penetration Energy Efficiency Case | $5,643 | $1,102 | 0.020% | | 17,191 | 0.021% | $4,085 | $664 | 0.016% |
| *RPS Cases with all Wind Components Produced in Michigan* | | | | | | | | | |
| RPS1-Wind | $5,642 | $455 | 0.008% | | 5,029 | 0.006% | $4,084 | ($113) | (0.003%) |
| RPS2-Wind | $5,643 | $1,627 | 0.029% | | 19,005 | 0.023% | $4,085 | $246 | 0.006% |

In Cases EE1 and EE2, electric prices per MWh are projected to climb slightly higher than those projected in the Base case by 0.7%-1.3% to compensate for reduced consumption. However, this price increase is more than offset by the decrease in electric consumption caused by energy efficiency measures. And, in time, electric prices decrease as well. The electric cost savings to consumers by 2020 in both the EE1 and EE2 cases are significant; by 2020 consumers in the EE1 case will be saving $510 million per year in out-of-pocket costs, whereas in the EE2 case consumers will be saving over $880 million per year in out-of-pocket costs. Table B shows the customer classes' annual electric cost savings for selected years, as compared to the Base Case. The effect of the energy efficiency programs on electric consumers as modeled in this study are summarized as follows:

- Through energy efficiency programs, residential electric costs are projected to be lower than the Base Case in 2020, projecting an average of 7.6% lower costs for EE1 and 14.3% lower costs for EE2 (see Table B).

- Commercial electric costs (Table B) are also projected to be lower than the Base Case in 2020, projecting 2.7% lower costs for EE1 and 4.3% lower costs for EE2.

- Industrial electric costs (Table B) are also projected to be lower than the Base Case in 2020, projecting 2.8% lower costs for EE1 and 4.4% lower costs for EE2.

[4] These figures represent a summation of the number of jobs created or eliminated within each year of the study.

**Table B - Annual Electric Cost Savings over Base Case (millions)**

| | 2010 | | 2015 | | 2020 | |
|---|---|---|---|---|---|---|
| **CASE EE1** | | | | | | |
| Residential | $77 | 2.2% | $165 | 4.7% | $275 | 7.6% |
| Commercial | $41 | 0.9% | $81 | 1.5% | $161 | 2.7% |
| Industrial | $20 | 0.9% | $38 | 1.6% | $74 | 2.8% |
| Total | $139 | 1.3% | $284 | 2.5% | $510 | 4.2% |
| **CASE EE2** | | | | | | |
| Residential | $144 | 4.2% | $314 | 9.0% | $518 | 14.3% |
| Commercial | $65 | 1.4% | $130 | 2.4% | $252 | 4.3% |
| Industrial | $32 | 1.4% | $62 | 2.5% | $117 | 4.4% |
| Total | $241 | 2.3% | $506 | 4.5% | $887 | 7.3% |

**The results of modeling potential energy efficiency programs indicate that Michigan's first energy policy decision should be to aggressively implement such programs. The results from Cases EE1 and EE2 show that all customer classes will experience a reduction in electric costs due to energy efficiency programs.** The results from these cases also show a positive impact on Michigan's economy even with program costs as high as $55/MWh. Thus the results of this Study show there is a significant benefit to all aspects of the State's economy and that it can be attained quickly and it is measurable.

## *RENEWABLE PORTFOLIO STANDARDS (RPS) WILL CAUSE MODERATE IMPROVEMENT IN MICHIGAN'S ECONOMY*

**The Study indicates that Michigan's economy will be slightly improved by the implementation of a 7% Renewable Portfolio Standard (Case RPS1) and will improve more with a 15% Renewable Portfolio Standard (Case RPS2).** The study projects that Michigan's GSP and employment levels will also improve with the implementation of a RPS, as shown in Table A.

- With Case RPS1, the NPV of Michigan's GSP over the period of 2007-2020, is projected to be higher by $194 million (0.003%) over the Base Case.
- With Case RPS2, the NPV of Michigan's GSP over the period of 2007-2020, is projected to be higher by $533 million (0.009%) over the Base Case.
- With Case RPS1 Michigan's employment levels over the period of 2007-2013 are projected to be higher by a total of 2,020 jobs over the Base Case.[5]
- With Case RPS2 Michigan's employment levels over the period of 2007-2013 are projected to be higher by a total of 6,381 jobs over the Base Case.[6]

With either Case RPS1 or Case RPS2, Table A shows disposable personal income is projected to decrease minimally (by less than 0.01%) from the Base Case The reduction in disposable personal income is due to the impact of higher energy prices and a shift in employment.

[5] See footnote 4.
[6] Ibid.

The long term impacts of renewable generation are not fully seen in the results presented in this Study. Renewable generation often has higher capital costs than traditional utility fossil generation. **Since, over time, the higher capital costs of renewable plants are often offset by lower fuel and operating costs of renewables, the RPS economic impacts projected in this study are likely conservative.** In Case RPS2, the construction cycle for renewables does not finish until 2025. The termination of modeling in 2025 prevents a proper assessment of the full impact of renewables. However, in Case RPS1, completion of the renewable construction and full incorporation of renewable capital costs is accomplished by 2016, thus providing a proper assessment of renewable's impacts during the modeling period.

It can be projected from Figure 1 for Cases RPS1 and RPS2, which increases in projected utility costs over the Base Case stabilize and then begin to fall back to the Base Case by 2020. For Case RPS1, the difference in electric costs from those of the Base Case reaches their maximum in 2018. The maximum utility costs occur shortly after the RPS requirement of 7% is reached in 2016. After 2018, the cost differential starts to decline since the fuel cost increases for the fossil generation built in the Base Case drive the electric costs higher in the Base Case. The correction occurs because, over time, the production costs associated with labor and fuel costs steadily increase the cost of traditional fossil fueled generation projects while the renewable generation project costs remain relatively flat. The costs of the renewable generation will continue to remain steady because many of the renewable energy sources, such as wind power, do not have fuel costs. This declining cost of renewables is not seen in Case RPS2 because the RPS target of 15% will not be reached until 2025 (beyond the reporting period of this Study). The analysis would need to be run until 2030 to observe the same positive effect resulting from Case RPS2 as is seen for Case RPS1.

**Based upon the conservative assumptions incorporated into this analysis, Michigan's economy will improve slightly under current market conditions with the implementation of Renewable Portfolio Standard as high as 15%.** With the burgeoning potential for national policy changes aimed at implementing $CO_2$ taxes, the expected increases in requirements demanding stricter emissions controls on traditional fossil generation, and the desired positioning of Michigan as a state attractive to alternative and renewable energy investment, the best available data suggests that Michigan should indeed adopt a RPS.

### *COMBINING AN ENERGY EFFICIENCY PROGRAM WITH A RPS WILL CAUSE THE LARGEST IMPROVEMENT IN MICHIGAN'S ECONOMY*

As can be seen in Table A, the combination of low penetration energy efficiency programs with a low RPS or moderate penetration energy efficiency programs with a moderate RPS both produce larger benefits to GSP and Employment then energy efficiency programs or RPS cases individually.

The moderate penetration energy efficiency and moderate RPS case, which are combined in Case EE2-RPS2, clearly provide the largest positive impact on GSP and Employment of the cases shown in Table A, excluding case RPS2-Wind. The NPV of the GSP over the period of 2006-2020, for Case EE2-RPS2, is projected to be higher then the Base Case by over $1.1 billion. The NPV of GSP for Case EE2-RPS2 is also shown to be $465 million higher (the difference between GSP for Case EE2-RPS2 and GSP for Case EE2) than the moderate penetration energy efficiency case (Case EE2) alone and over $568 million higher (the difference between GSP for Case EE2-RPS2 and GSP for Case RPS2) than the moderate RPS case (RPS2) alone.

- The REMI model also predicts that the highest employment figure will be achieved through Case EE2-RPS2, with the exception of Case RPS2-Wind.

- Employment for Case EE2-RPS2 is projected to average over 1,220 jobs higher than the Base Case through 2020, 367 jobs higher then Case EE2 and 772 jobs higher than Case RPS2.

- The NPV for disposable personal income for Case EE2-RPS2 over the period studied is predicted to be $664 million higher than the Base Case. This is lower than for Case EE2 because of the effects of RPS2.

- Implementation of a moderate penetration energy efficiency program combined with a moderate RPS will reduce fossil fuel imports by over 20% by 2020[7].

**The economic improvements associated with Case EE2-RPS2 surpass the other cases by combining lower electric costs to consumers due to the energy efficiency programs with the economic benefits of constructing numerous renewable energy projects.** In addition, the reduction in imports of fossil fuels through a greater reliance on indigenous resources provides enhanced economic benefits to the State. These economic benefits do not include the value associated with carbon credits, the impact of potential carbon taxes, and the cost impacts of adding as yet unknown and unplanned air emissions upgrades to fossil plants (above that assumed in this study). If these eventualities were included, the economics detailed in Case EE2-RPS2 would show an even greater improvement over the Base Case.

## *TOGETHER, ENERGY EFFICIENCY PROGRAMS COMBINED WITH RPS WILL SIGNIFICANTLY REDUCE MICHIGAN'S $CO_2$ EMISSIONS*

The reduction in Michigan's air emissions from the adoption of energy efficiency programs and a Renewable Portfolio Standard is significant. Regarding emissions, this Study focused only on $CO_2$.

- The modeling in ENERGY 2020 shows that by implementing energy efficiency and renewable energy, annual $CO_2$ emissions would be reduced by as much as 18.7% in 2020 (Cases EE2 and RPS2 combined).[8]

- Table C shows the reduction in $CO_2$ emissions for each case from that of the Base Case. Implementation of the moderate penetration energy efficiency case (EE2), coupled with a moderate RPS (RPS2) could eliminate over 96 million metric tons of $CO_2$ emissions between now and 2020.

- In today's carbon markets, the reduction of $CO_2$ emissions has a credit value of about $4.20 per metric ton (MT). At this price, the value to Michigan of the reduction of 96 million metric tons of $CO_2$ emissions for Case EE2-RPS2 is approximately $404 million.

[7] See Table 4.1.
[8] See Table 5.1.

Table C shows the value of reduced $CO_2$ emissions for each of the cases in the Study. The amount of $CO_2$ reduction is cumulative over the period of 2007-2020. **This Table indicates that the monetary value of reduction in $CO_2$ emissions would be substantial if Michigan chooses to enact any of the cases.** In so doing, the value of the carbon reduction credits could be used to offset a portion of the costs of generating renewable energy.

**Table C - Value of Michigan's Potential CO2 Reductions Based on $4.20/MT**

| | Total CO2 Reduction from Base Case 2007 thru 2020 | | Value of CO2 at Todays Market Price |
|---|---|---|---|
| | millions of Metric Tons | Reduction | ($millions) |
| **EE1** | **36.401** | **3.0%** | **$152.88** |
| **EE2** | **60.506** | **5.0%** | **$254.12** |
| **RPS1** | **20.448** | **1.7%** | **$85.88** |
| **RPS2** | **27.578** | **2.3%** | **$115.83** |
| **EE1-RPS1** | **60.406** | **5.0%** | **$253.71** |
| **EE2-RPS2** | **96.294** | **8.0%** | **$404.43** |

As has become more evident and urgent every day, the issue of global warming is increasing the interest in curbing carbon emissions. There is growing support in many business sectors and the government for a carbon tax. In a January 24, 2007, Wall Street Journal article, business columnist Holman W. Jenkins, Jr. stated:

> *"A carbon tax would be the most efficient way of encouraging businesses and consumers to make less carbon intensive-energy choices. Government would not have to exercise an improbable clairvoyance about which technologies will pay off in the future. There'd be less scope for Congress to favor some industries over others purely on the basis of lobbying clout."*[9]

Additionally, California's recent enacted legislation has aimed at reducing carbon emissions for the state to 1990 levels by the year 2020. The California Air Resources Board will be developing regulations and market mechanisms to achieve that goal.

For a detailed analysis of the net economic impacts to Michigan's economy associated with the implementation of various greenhouse gas reduction strategies, see "Michigan at a Climate Crossroads", University of Michigan Center for Sustainable Systems, April 2007 (Report No. CSS07-02).

## *MANUFACTURING RENEWABLE ENERGY COMPONENTS WILL IMPROVE MICHIGAN'S ECONOMY*

The inclusion within the Study of additional cases incorporating the manufacturing of renewable energy components in Michigan illustrate the potential benefits of exploiting Michigan's vast manufacturing infrastructure. Cases RPS1Wind and RPS2Wind assume that all components required for wind energy systems required in Cases RPS1 and RPS2 are satisfied by manufacturers located in Michigan. These cases use the results from ENERGY 2020 for Cases RPS1 and RPS2 and adjust the allocation of renewable components to be produced from Michigan resources only. Strictly as an illustration, the results demonstrate, as expected, that the attraction of additional manufacturing of wind components to Michigan would improve the State's economy. In reality, not all components could be expected to be manufactured in Michigan. However, the specific wind energy component products that could be manufactured

[9] Jenkins,, Jr. Holman W. (January 24, 2007), Decoding Climate Politics, Wall Street Journal (New York), pp A12.

in Michigan would also be available for sale to wind projects located outside of Michigan. This incremental benefit was ignored in the analysis.

- The modeling of RPS1-Wind with Michigan manufacturing improves the NPV of Michigan's GSP for the period between 2007 -2020, over the Base Case by about $455 million and $260 million over Case RPS1.

- **The modeling of RPS2-Wind with Michigan manufacturing improves the NPV of Michigan's GSP for the period between 2007 -2020, over the Base Case by over $1.6 billon and $1.1 million over Case RPS2.**

- Employment levels for Case RPS2-Wind are the highest of all cases studied and the increase in employment levels over the Base Case is nearly 3 times higher than Case RPS2.

- Further evidence of the benefits of attracting renewable energy manufacturing can be seen in the disposable income figures shown in Table A. The NPV of disposable income for the period of 2006 to 2020 increases by $346 million for Case RPS2-Wind over that of Case RPS2. This change is due to the creation of new jobs in the renewable energy manufacturing sector.

## Summary of Study Conclusions

The following is a brief a summary of the conclusions from this Study:

1. Implementation of energy efficiency programs at the levels included in the 21st CEP will result in significant economic benefit to Michigan over the Base Case.

2. Economic impacts (GSP and employment) from an RPS are likely to be positive over the life cycle of renewable power generation plants (versus fossil generation plants).

3. During specified periods within the Study's timeline, minimal negative impact to Disposable Personal Income (DPI) is projected to occur in certain of the RPS-only cases. Due to the long term reduction in fuel and operating costs of renewable assets, improved economic results for all energy efficiency and RPS cases are likely, if the study timelines were extended to encompass the entire useful life of the power generation assets.

4. A combined Energy Efficiency and RPS will reduce the need for new coal generation and its associated emissions and environmental impact.

5. Emission reductions illustrated in all the cases studied are significant and could have significant value to Michigan's residents, above that reflected in the calculations of GSP, employment and DPI.

6. If a state or national RPS were to be put in place, Michigan could gain considerably relative to other states since it is a superior location for wind resources, manufacturing job potential and investment.[10]

[10] These findings correlate well to a recent report issued by the Renewable Energy Policy Project (REPP) in November 2006, entitled "Component Manufacturing: Michigan's Future in the Renewable Energy Industry". The report provides a detailed county and individual site level account of manufacturing potential for wind, solar,

This study shows that Michigan will economically benefit significantly from implementation of energy efficiency programs. In addition, even with the conservative assumptions utilized, RPS impacts are moderately positive. The primary cause for concern regarding future electric power supplies are associated with fossil generation cost uncertainties. Projections for the capital cost of new coal generation continue to increase and coal supply constraints are likely to increase fuel costs. The potential for a national cap on $CO_2$ emissions is real and, if enacted, will cause an increase in electric costs from fossil generation.

Michigan should consider becoming an early implementer of energy efficiency and RPS to start reducing its $CO_2$ emissions as soon as possible. This could put the State in a position to create a valuable new asset: accumulated $CO_2$ emission credits, in advance of a national $CO_2$ emissions cap. In the future this asset maybe used to support existing and future Michigan manufacturing through applications of accumulated $CO_2$ emission credits as a $CO_2$ emissions offset. The result would be a lowering of manufacturing costs for Michigan-based industries.

geothermal, and biomass energy systems in Michigan, and concludes that there are 2,050 firms in Michigan with the potential to manufacture renewable energy components. In addition, the report determined that, to satisfy a national renewable energy requirement of 124,900 MW, these firms would require incremental investment in excess of $5 Billion, and add 34,777 new full-time equivalent jobs.

# 1 Project Background

This Study was commissioned by the Michigan Public Service Commission (MPSC) with the stated objective of evaluating the net economic impact on Michigan from the increased use of energy efficiency along with increased installation of renewable electric generation. Funding was provided by the Herbert H. and Grace A. Dow Foundation and the MPSC through the Low Income/Energy Efficiency (LI/EE) Program.

## 1.1 Project Rational

There were several factors driving the need for this Study. First and foremost, Michigan is at a crossroads regarding its ability to reliably supply electricity to its residents. For years the electricity consumed by Michigan has exceeded the amount that is generated from Michigan power plants. The electric consumption situation has reached the point at which electric reliability is a concern, and it has become apparent that Michigan needs additional generation sources. Recognizing the situation, Michigan Governor Jennifer Granholm requested the MPSC to develop a comprehensive electric energy plan (21$^{st}$ Century Energy Plan) for Michigan by the end of 2006. The 21$^{st}$ Century Energy Plan ("21$^{st}$ CEP") concluded that, if Michigan stays on its current course, it will need to add a significant number of new generation facilities. Thus, the impetus to evaluate economic impacts of energy policies for the State of Michigan is timely and appropriate.

Second, the United States dependence on foreign sources of energy to power our economy continues to dramatically increase. President George W. Bush said as much early in 2006 when he declared that "America is addicted to oil."[11] The impacts of this dependence are significant and carry far-reaching implications for foreign policy, national security, economic competitiveness, public health and our environment. Michigan, as a state with limited supplies of fossil fuels, currently imports 90% of our primary energy sources (oil, coal, natural gas and uranium) at a cost exceeding $18 billion per year.

While we as a society have been "addicted" to oil for quite some time, this stark realization has only come into focus recently as the price of oil, coal and natural gas have risen dramatically and in some cases are at all-time highs. This steep rise in prices is due to many factors including infrastructure limitations, natural disasters and surging economic growth in some areas of the developing world, creating world-wide demand which will eventually outstrip supply. There is no denying that the inability of energy supply to keep up with demand is playing a growing role in global history. One of the primary reasons supply has lagged is that it is becoming harder and harder to find new fossil sources, in particular, new oil and gas reserves. Though we are not going to run out of oil immediately, or deplete the world's supply of natural gas or coal anytime soon, what has become clear is that our overdependence on these sources – our "addiction" – is increasingly dangerous and damaging to our economy, national security and environment. Thus, the availability of fuel sources, and our dependency on imported

[11] State of the Union Address, January 31, 2006.

fuel, is a key factor in assessing the impact of alternative measures on Michigan's economy.

Third, environmental impact of electricity generation with fossil fuels continues to be a concern. The public is becoming more and more aware of the effects of global warming. This is evidenced by the adoption of Renewable Portfolio Standards in other states. There are now 24 states that have instituted some sort of Renewable Portfolio Standard (RPS) requiring their electric utilities to source a certain percentage of their electricity from clean technologies like wind, solar and biomass. California Governor Arnold Schwarzenegger signed a bill, the Global Warming Solutions Act, in October 2006, effectively limiting emissions of greenhouse gases like $CO_2$ from sources inside – and in some cases even outside – the state.[12]

Fourth, the cost of electricity has risen dramatically over the last several years due to increased fuel costs. As an example, Consumers Energy's coal costs increased from about $14.159/MWh in 2004[13] to $20.557/MWh in 2007.[14] This is a 45% increase in just three years. New electric generation facilities will be expensive to build and operate. These price increases for electricity change the economics of energy efficiency programs, demand side management programs and RPS programs. The economic impacts of both types of programs are not yet fully understood. Therefore, the time to evaluate such policy changes is now.

In 2004, the MPSC launched the Michigan Renewables Energy Program (MREP) to promote the use of renewable energy in Michigan. Also in 2004, a number of Michigan agencies came together to form the Economic Development and Growth Through Environmental Efficiency (EDGE2) Committee, under the leadership of the Michigan Department of Environmental Quality. Resulting from recommendations developed through EDGE2, Governor Granholm issued two Executive Directives to promote renewable energy, including the development of a RPS. The efforts of these work groups, which included well-respected experts and leaders in the areas of energy, clean technology and government policy, concluded that one of the greatest problems Michigan faces with respect to the effective deployment of renewable energy sources and energy efficiency programs is the lack of accurate data associated with energy efficiency and renewable energy generation and their respective impacts on Michigan's economy as a whole.

This study is designed to answer many of the questions regarding how policies promoting energy conservation programs and a RPS will impact Michigan's economy and its residents.

## *1.2 The 21st Century Energy Plan*

In April of 2006, Michigan Governor Jennifer Granholm called for the development of a comprehensive state energy plan for the 21st century through Executive Directive 2006-

[12] http://gov.ca.gov/index.php?/press-release/4111/
[13] See MPSC Case U-13917, Exhibit A-___ RJP-2, pg 1.
[14] See MPSC Case U-15001, Exhibit A-15 (RJP-2), pg 1.

2.[15] On January 31, 2007, the 21$^{st}$ Century Energy plan was delivered to the Governor by MPSC Chairman Peter Lark. The authors of the 21$^{st}$ CEP were asked to articulate the following solutions:

- The State's short-term and long-term electric needs for residential, industrial, commercial, and governmental customers shall be met in an optimum manner that assures a reliable, safe, clean, and affordable supply.

- The future development of Michigan's electric infrastructure shall further the State's competitive business climate, grow jobs, and provide affordable rates for all customers.

- The appropriate use and application of energy efficiency, alternative energy technology, and renewable energy technologies shall be consistent with the goal of assuring reliable, safe, clean and affordable energy.

- This State's natural resources and the environment shall be protected from pollution, physical or visual impairment, or destruction, and future risks associated with fossil fuels shall be mitigated.

- A renewable portfolio standard shall be created that establishes targets for the share of Michigan's energy consumption that must be derived from or produced by renewable energy sources.

- New technology options to generate, transmit, or distribute energy more cleanly or more efficiently shall be identified.

- Foster in Michigan the State's economic interest by ensuring development of the intellectual capital, financing, infrastructure, and other resources necessary for continued growth of alternative and renewable energy technologies.

- The plan shall identify any legislative or regulatory changes necessary to its implementation, together with any financial, funding, or incentive mechanisms needed to best position the state to meet the energy challenges of the future.

This collaborative process, which involved representatives from utilities, consumer groups, independent power producers, renewable energy advocates and many others, was kicked off in early 2006. The project was organized into several working groups – CNF Update, Renewables, Energy Efficiency and Alternative Technologies. Each working group was responsible for updating any assumptions made in its area in the original CNF report. The Renewables, Energy Efficiency and Alternative Technologies work groups were also to develop "straw man" policy recommendations which could be considered by the state legislature for enactment in order to further the development of the market for, or encourage adoption of, those technologies.

[15] http://www.michigan.gov/gov/0,1607,7-168-36898-140415--,00.html

Because the 21st Century Energy Plan developed by the MPSC does not consider the overall economic impacts of each case included in its report, or of any policy recommendations made, this Study's focus on economic ramifications supplies knowledge not presented in the 21st CEP. However, in order to ensure that the results of both this Study and the 21st CEP can be compared and considered in a uniform light, efforts were made to ensure that the assumptions that went into each effort were consistent and that the calculation and forecasting methodology used are as similar as possible. Combining the knowledge contained in the 21st CEP with the economic data in this Study permits Michigan to construct a comprehensive plan that addresses both policy and economic issues.

# 2 Project Methodology

The Study integrated two sophisticated modeling and forecasting tools – one to model the energy system in Michigan (specifically the electricity sector,) and one to model Michigan's economy.

To analyze impacts and gain insight into how more renewable electric generation along with more efficient electricity consumption impacted economic factors, a case modeling approach was taken. Cases were developed using policy mechanisms as structural bases and based on approaches that have been used in other states or have been proposed for use in Michigan.

## *2.1 Model Selection*

In early 2005, a group of MBA students at the Stephen M. Ross School of Business at the University of Michigan performed a Multidisciplinary Action Project (MAP Project) for NextEnergy. The project focused on defining renewable energy policy impacts on Michigan's economy and employment. The MAP Team assessed the current energy environment in Michigan, reviewed the impacts of various renewable energy policies currently in place in over 20 states and evaluated numerous energy-economy models to meet the unique needs Michigan. It quickly became clear that no one modeling tool existed that would perform the desired two-pronged analysis – that is, no single modeling tool could perform both the energy modeling and the economic modeling and provide an integration of the two sets of findings. The MAP Team recommended a bilateral approach to modeling the energy system in Michigan. Part one of the approach involves the ENERGY 2020-REMI integrated energy-economy model combination.

Ultimately, NextEnergy developed a request for proposal (RFP) which was sent to several of the energy and economic modeling companies and organizations. Proposals were received from two organizations and Systematic Solutions, Inc. (SSI) was selected. SSI proposed to use its own proprietary energy modeling tool, ENERGY 2020 in conjunction with the Regional Economic Models, Inc. (REMI) Policy Insight economic model to perform the work.

**ENERGY 2020**[16] **-** ENERGY 2020 uses detailed models specializing in specific utility operations such as econometric forecasting, financial analysis and supply planning, and the labyrinthine iteration process required to "integrate" these models for policy development and testing. It is a mature, well-established, comprehensive planning and policy analysis tool designed especially for case analysis. The model allows analysts and planners to resolve issues and sort potential strategies in an efficient and comprehensive manner, allowing the planner to quickly incorporate a tremendous amount of information into the decision making process. ENERGY 2020 provides a comprehensive and consistent planning framework that realistically simulates all important components of the energy companies and their customers, providing a complete and balanced

[16] http://www.ENERGY 2020.com/energy.htm

representation of each group. More details on ENERGY 2020 are contained in Appendix D.

> **Model Use:** ENERGY 2020 was primarily used to model Michigan's electric supply system. Its purpose was to produce energy costs, plant building cases, electric price differentials, emissions, and other factors as input into REMI. It also performed the final analysis of the REMI results to determine any economic impacts which effect electric consumption.

**REMI Policy Insights**[17] **-** Policy Insight's REMI model has the unique power to generate realistic year-by-year estimates of the total regional effects of any specific policy initiative. The Policy Insight model is a general equilibrium model designed to give policy-makers information on the potential economic impacts of various government policy actions. A wide range of policy variables allow the user to represent each policy to be evaluated, while the explicit structure in the model helps the user to interpret the predicted economic and demographic effects. The model is calibrated to many sub-national areas for policy analysis and forecasting, and is available in single- and multi-area configurations. Each calibrated area (or region) has economic and demographic variables, as well as policy variables so that any policy that affects a local economy can be tested. More details on the REMI Model are contained in Appendix D.

The particular version that we used treats the state of Michigan as one region. Use of the model for policy analysis follows the following four steps:

1) Formulate a policy question.
2) Generate a baseline forecast.
3) Generate an alternative forecast with affected policy variables.
4) Compare the 2 forecasts.

The baseline forecast is created by running a "Control" analysis with the model. Then a policy simulation that uses our specific control as the baseline forecast is run and compared to the model output that results from changing policy variables. The output can be displayed as a final level, an absolute change, or a percentage change. For example, it can be shown that a policy will result in a total employment level in Michigan of 5,100,000 people, which translates into an increase of 100,000, or an increase of 2%. The values are calculated on an annual basis over a user-defined time period, with the model forecasting through the year 2025.

> **Model Use:** REMI was used to look at how changes in energy costs, manufacturing, and construction spending affected Michigan's economy.

## 2.2 Case Development

Both this Study and the 21st CEP utilized a case approach. While several of our cases roughly match 21st CEP Cases, no attempt was made to match up every case exactly. The Base Case in this Study very closely matches the 21st CEP's Base Case. This Study was

[17] http://www.remi.com/software/software.shtml#PolicyInsight

started prior to the MPSC's efforts to study the Michigan's future energy needs in the 21st CEP. Differences in the modeling capabilities of ENERGY 2020 and the models used in the 21st CEP prevent a perfect match in the data inputs and results. The differences between the modeling of this Study and the 21st CEP are minor and will not impact this Study's conclusions or their relevance to the 21st CEP recommendations. In addition, the purpose of this Study is to assess the impacts on Michigan's economy of policy changes relating to energy efficiency and renewable energy. This Study focuses on the difference the policy change causes to the Base Case's energy supply model and how those differences translate into economic impact on Michigan. Minor differences between the models used in this Study and the models used in the 21st CEP are inconsequential to the Study's overal results because these minor differences will be included in all Cases.

Cases were developed to represent the range of potential impacts from increased use of renewable sources of electricity and/or increased efficiency of electricity consumption. Two policy frameworks were chosen to represent the mechanisms through which renewable electricity and energy efficiency would be adopted within the State. Energy efficiency programs were funded through a levelized cost included in the utility cost structure. For renewable electricity, the assumption is that the MPSC and utilities will implement a Renewable Portfolio Standard (RPS) and charges for renewable energy would be included in the costs paid by utility customers. The actual modeling of these funding mechanisms will be discussed further in the section on modeling. Based upon these types of programs, the following nine cases were modeled in this Study:

- **Base Case**: A Michigan electric generation profile based upon historic data with future generation needs provided for in the traditional utility manner of adding a mix of new fossil fueled generation (including electricity purchased from out of state sources).

- **Low Penetration Energy Efficiency Case ("EE1")**: A profile in which Michigan implements low penetration energy efficiency programs that reduce electric consumption by an average of 443 GWh each year (a total of 7,344 GWh over the forecast period) at a cost of $55.81/MWh. This model of energy efficiency programs reflects lower energy efficiency targets at higher program costs per results.

- **Moderate Penetration Energy Efficiency Case ("EE2")**: A profile in which Michigan implements moderate penetration energy efficiency programs which reduce electric consumption by an average of 755 GWh each year (a total of 12,827 GWh over the forecast period) at a cost of $27.74/MWh.[18]

- **Low RPS Case ("RPS1")**: A profile in which Michigan implements a low renewable portfolio standard (RPS) that grows to 7% of total electric sales by 2016 and remains at 7% beyond 2016.

[18] This case reflects energy efficiency recommendations very similar to those found in Michigan's 21st Century Energy Plan.

- **Moderate RPS Case ("RPS2")**: A profile in which Michigan implements a moderate renewable portfolio standard that grows to 15% of total electric sales by 2025 (achieving an 11% RPS in 2020).

- **Combined Low Penetration Energy Efficiency & Low RPS Case ("EE1-RPS1")**: This case represents a combination of Case EE1 and Case RPS1.

- **Combined Moderate Penetration Energy Efficiency & Moderate RPS Case ("EE2-RPS2")**: This case represents a combination of Case EE2 and Case RPS2.

- **Low RPS Case with Michigan Manufacturing ("RPS1-Wind")**: In this Case RPS1 is modeled to assume that all required wind system components required to satisfy Michigan's RPS are manufactured in Michigan.

- **Moderate RPS Case with Michigan Manufacturing ("RPS2-Wind")**: In this Case RPS2 is modeled to assume that all wind system components required to satisfy Michigan's RPS are manufactured in Michigan.

The last two Cases, RPS1-Wind and RPS2-Wind were added to study the impacts on Michigan's economy of adding Michigan wind power component manufacturing to the model. Cases RPS1-Wind and RPS2-Wind assume that 100% of the components of Michigan's renewable wind generation facilities are manufactured in Michigan. These cases were based upon initial findings in RPS1 and RPS2 and are intended to evaluate the sensitivity to the overall state economy of an aggressive push to manufacture renewable energy components in Michigan.

As of February 2007, 24 states and the District of Columbia have implemented some sort of RPS. As discussed earlier, a significant amount of data is available concerning the costs and potential for renewable energy sources. The 21st CEP Renewable Energy Workgroup ("REP") did a comprehensive study of Michigan's immediate potential for renewable energy production and accumulated costs for those resources. This Study relied upon that information for much of its modeling efforts[19].

## 2.3 Data Sources

Data required for the Michigan ENERGY 2020 model and Michigan REMI model were collected from several sources. The initial data on Michigan's energy system was taken directly or derived from the Capacity Need Forum (CNF) report produced by the MPSC in January, 2006. This was updated with the October 2006 data from the 21st CEP CNF Update Workgroup.

In order to ensure that the results of both efforts can be compared and considered in the same light, we made every attempt to ensure that the assumptions that went into each effort were consistent and that the calculation and forecasting methodology used for both were as similar as possible. Section 4.0 lists the key assumptions that were made in the

[19] See the 21st CEP Renewable Working Group's website: http://www.dleg.state.mi.us/mpsc/electric/capacity/energyplan/renewables/renewables.htm

CNF, the 21st CEP, in ENERGY 2020 and in REMI. Below is a summary of the general assumptions used in this Study:

1) **Energy Demand –** the forecasted energy demand used in the 21st CEP was used in this Study
2) **Energy Efficiency –** the impacts and costs of energy efficiency and demand side management programs were based upon the 21st CEP models. Reductions in energy consumption and demand reductions, as well as program costs were levelized over the period of time addressed in this Study.
3) **Renewable Energy Technology –** minor adjustments were made to certain capital and operating cost factors for some of the renewable energy technologies to comport with the modeling requirements of ENERGY 2020 and REMI. The adjustments are related to the spreading of renewable construction costs over the expected construction period of the renewable projects. This was done to levelize the construction spending in a manner that was more realistic than assuming all the costs occurred in the year in which the project went into operation.

Data on renewable energy such as technology costs, capacity factors, heat rates and Michigan market potential was also derived primarily from the CNF report and the Renewables Work Group of the 21st CEP. Some data was derived from industry sources including interviews with wind and biomass project developers.

Energy efficiency programs modeling was performed on uniform annual basis, as explained below:

- Annual changes in energy consumption and demand reductions were set identical for each year of the model. The reduction in energy consumption and demand was cumulative over the period of 2007 through 2025. Thus, the reduction in energy consumption from the Base Case for 2008 was two times the amount in 2007 (first year of energy reduction) and the amount of energy reduction from the Base Case in 2009 was three times the energy reduction in 2007.
- Costs for the energy efficiency measures were levelized over the period of the Study. All energy efficiency costs were calculated on a $/kWh basis and included in utility costs by multiplying the kWh reduction by the cost.

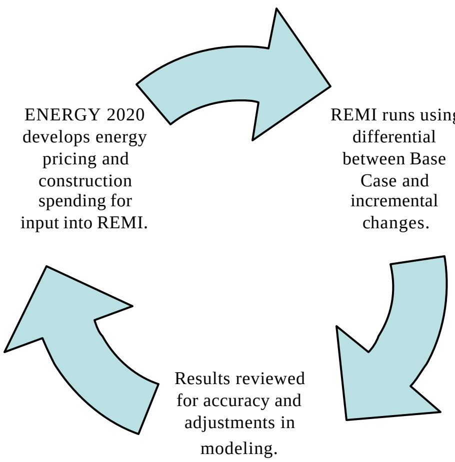
Renewable generation was modeled to add generation on a levelized basis between 2007 and the target date. The following explains the modeling methods used in the RPS cases:

- Renewable targets were set based upon a percentage of electric sales and exclude line losses.
- The renewable targets were set at the end of the year of the RPS target. Thus, the installation of renewables to meet the 7% RPS target for 2015 does not occur until the end of 2015. This causes the number of renewable kWh to not reach the target level until the year following the renewable target.
- Both Case RPS1 and RPS2 additions of renewable generation were identical up through the end of 2016.

- The increase in RPS from 7% to 15% for Case RPS2 was averaged over the period between 2015 and 2025.
- Renewable generation costs were capitalized and added to utility cost recovery in the year in which the renewable generation was placed in service.

## *2.4 Modeling*

The modeling in this Study was done in two separate efforts. The first sets of runs were performed in the summer of 2006 using the data from the Capacity Needs Forum (CNF) report of January 2006. In September 2006 it was revealed by the 21st CEP that much slower electric growth rates, higher project capital costs and higher operating costs were anticipated. It was decided that the differences were significant and the models needed to be run again based upon the 21st CEP data. A second set of model runs were performed in October 2006 which incorporated the 21st CEP electric load forecast, generation capacity additions and costs. Review of the preliminary results with the MPSC in October 2006 resulted in some adjustments to the data used for the modeling. The final sets of runs were completed in December 2006. Below is a summary of the modeling runs:




- Model Run 1 – Based on the CNF data from January 2006. This incorporated an average annual electric growth projection of 1.9%.[20]
- Model Run 2 – Based on the 21st CEP data from September 2006. Major changes included:
    - Reduction in average annual growth rate to 1.2%.[21]
    - Increases in new construction costs; higher projected fuel and operating costs.
    - Added a case which assessed the impact of manufacturing RPS components in Michigan.
    - Reduced the moderate RPS case 2025 target from 20% to 15%.
    - RPS additions above the 2015 level of 7% were assumed to be provided by wind generation only.

The modeling effort focused on differences between a Base Case and each of the other cases reviewed. The base REMI model was based on actual 2004 Michigan economic conditions. From this, the Base Case was established by combining the historic REMI database with the forecasted energy impacts. Once the Base Case was established, all inputs to REMI were based on the “differences” from the Base Case. REMI then modeled the economic impact on Michigan caused by those differences.

The modeling required several iterations between ENERGY 2020 and REMI because as Michigan’s economy changes, so do its electric requirements. The first runs were of the

[20] Michigan Capacity Need Forum: Staff Report to the Michigan Public Service Commission, page 19.
[21] 21st Century Energy Plan Capacity Needs Forum Update Workgroup Resource Assessment Draft, page 34.

21st CEP Base Case to establish the Base Case model. The first step in developing the Base Case was to incorporate the 21st CEP Base Case data into ENERGY 2020. Results from ENERGY 2020 were then run through REMI to produce the economic results. Usually there was one round of runs to ensure the results of the two models converged on the same solution set. REMI projects economic activity which affects electric consumption. The economic activity results from REMI were used to adjust the projected electric consumption in ENERGY 2020, which in turn also affected the power plant construction and electric price projections. These results were then incorporated back into REMI model to determine if they had any significant impacts on economic activity. Once the ENERGY 2020 results no longer have an impact on the REMI results, the models converged. The final result of the Base Case was used to measure the impacts on Michigan's economy caused by the other cases.

Subsequent cases employed the same modeling process as the Base Case modeling described above. Each iteration was reviewed to look for inconsistencies and modeling errors. The analysis of the modeling results for each Case studied focused on the changes an energy efficiency or RPS policy would have on the Base Case. Focusing the analysis and Study on the differences between each case and the Base Case provides the most useful analysis of policy impacts because it prevents variables outside the scope of this report from impacting the Study results.

# 3 Modeling Data

## 3.1 Base Case

The data used in this Study's Base Case was matched as close as possible to the 21st CEP Base Case. The purpose of developing similar models was to establish a set of parameters and a model that was as similar as possible to the 21st CEP Base Case for measuring the impacts on Michigan's economy of energy efficiency and RPS policies. The Base Case and 21st CEP projected electric sales for Michigan are shown in Table 3.1[22]. The first set of columns is the load forecast included in the 21st CEP Central Station. The second set of columns show the load forecast used in the ENERGY 2020 Base Case. As can be seen in Table 3.1, the difference between the 21st CEP Base Case and the ENERGY 2020 Base Case is between -1.28% and 0.97%. Most of this difference is due to ENERGY 2020's treatment of a portion of Michigan's Upper Peninsula load as part of Wisconsin. These differences are minimal and will not impact the conclusions contained in this report.

**Table 3.1- Base Case Projected Electric Requirements (GWh)**

| | 21st Century Energy Plan Base Case Sales Projections | | | | Energy 2020 Sales Projections | |
|---|---|---|---|---|---|---|
| Year | Southeast Michigan | Balance of Lower Peninsula | Upper Peninsula | Total Requirements | ENERGY 2020 Michigan Sales | Difference from 21st CEP Base Case |
| 2006 | 55,417 | 50,240 | 6,526 | 112,183 | 111,096 | 0.97% |
| 2007 | 55,606 | 50,850 | 6,565 | 113,021 | 112,323 | 0.62% |
| 2008 | 55,967 | 51,901 | 6,624 | 114,492 | 114,036 | 0.40% |
| 2009 | 55,839 | 52,888 | 6,684 | 115,411 | 115,291 | 0.10% |
| 2010 | 56,454 | 53,693 | 6,754 | 116,902 | 116,404 | 0.43% |
| 2011 | 57,130 | 54,491 | 6,821 | 118,442 | 118,506 | -0.05% |
| 2012 | 58,003 | 55,366 | 6,875 | 120,245 | 120,588 | -0.29% |
| 2013 | 58,718 | 56,038 | 6,929 | 121,685 | 122,554 | -0.71% |
| 2014 | 59,569 | 56,837 | 6,991 | 123,396 | 124,564 | -0.95% |
| 2015 | 60,304 | 57,665 | 7,053 | 125,023 | 126,620 | -1.28% |
| 2016 | 61,073 | 58,622 | 7,116 | 126,811 | 126,776 | 0.03% |
| 2017 | 61,830 | 59,170 | 7,180 | 128,180 | 127,089 | 0.85% |
| 2018 | 62,780 | 59,959 | 7,243 | 129,982 | 128,876 | 0.85% |
| 2019 | 63,717 | 60,752 | 7,306 | 131,775 | 130,792 | 0.75% |
| 2020 | 64,674 | 61,677 | 7,370 | 133,721 | 132,723 | 0.75% |
| 2021 | 65,647 | 62,375 | 7,434 | 135,456 | 134,920 | 0.40% |
| 2022 | 66,635 | 63,195 | 7,499 | 137,329 | 136,796 | 0.39% |
| 2023 | 67,641 | 64,021 | 7,564 | 139,226 | 138,695 | 0.38% |
| 2024 | 68,662 | 64,972 | 7,632 | 141,266 | 140,789 | 0.34% |
| 2025 | 69,701 | 65,692 | 7,701 | 143,094 | 142,894 | 0.14% |

The Central Station case and this Study's Base Case both assume that only existing installed energy efficiency measures and renewable generation are implemented in Michigan. Efficiency improvements based on increasing impacts of federal appliance standards and the continuation of the historical trend toward greater efficiency per unit output in industrial sectors are included in the forecast. The projected generation plant

[22] 21st Century Capacity Needs Forum Update Workgroup, Resource Assessment Draft Nov. 15, 2006, Appendix A, Page 3, Table A1.

additions needed to meet the projected load for the Base Case are shown in Table 3.2. These generation capacity additions are similar to those used in the 21st CEP Base Case model, but are not identical. Since this Study is focusing on the impacts on Michigan's economy of energy efficiency and RPS policies and the analysis is on the differences between each policy case and the Base Case, the differences between the 21st CEP's Central Station and this Study's Base Case will not impact the Study's results. It is important to develop a Base Case that is as close as possible to the 21st CEP's Central Station so that the base economic parameters used in REMI are valid. As can be seen in Table 3.2, the Base Case does not include the addition of any new renewable energy generation sources.

**Table 3.2 – ENERGY 2020 Base Case Capacity Additions and Retirements (MW)**

| | CT & Combined Cycle | Pulverized Coal | Total Added | Capacity Retired | TOTAL INSTALLED CAPACITY |
|---|---|---|---|---|---|
| **2006** | 0 | 0 | 0 | 0 | 27,475 |
| **2007** | 0 | 0 | 0 | 0 | 27,475 |
| **2008** | 480 | 0 | 480 | 0 | 27,955 |
| **2009** | 160 | 0 | 160 | 0 | 28,115 |
| **2010** | 320 | 0 | 320 | 0 | 28,435 |
| **2011** | 320 | 0 | 320 | 0 | 28,755 |
| **2012** | 160 | 500 | 660 | 0 | 29,415 |
| **2013** | 160 | 500 | 660 | 61 | 30,014 |
| **2014** | 160 | 500 | 660 | 0 | 30,674 |
| **2015** | 0 | 500 | 500 | 249 | 30,925 |
| **2016** | 0 | 1,000 | 1,000 | 226 | 31,700 |
| **2017** | 0 | 500 | 500 | 102 | 32,098 |
| **2018** | 0 | 500 | 500 | 162 | 32,436 |
| **2019** | 0 | 1,000 | 1,000 | 46 | 33,390 |
| **2020** | 0 | 500 | 500 | 155 | 33,735 |
| **2021** | 0 | 1,000 | 1,000 | 402 | 34,333 |
| **2022** | 0 | 1,000 | 1,000 | 269 | 35,064 |
| **2023** | 0 | 1,000 | 1,000 | 327 | 35,737 |
| **2024** | 0 | 500 | 500 | 260 | 35,977 |
| **2025** | 500 | 0 | 500 | 0 | 36,477 |
| **TOTAL** | 2,260 | 9,000 | 11,260 | 2,258 | 36,477 |

Capital costs for the various types of power projects are presented in Table 3.3.[23]

[23] 21st Century Energy Plan Appendix II, Table 3, pg 15, January 31, 2007.

**Table 3.3 - Plant Construction Cost**

| | Size | $/kW Base | Capital (2006$) | Fixed O&M (2006$) | Variable O&M (2006$) | Design Heat Rate BTU/kWh |
|---|---|---|---|---|---|---|
| **Pulverized Coal** | 500 | 1,230 | 1,478 | 44.26 | 1.86 | 9,496 |
| **Fluidized Bed** | 300 | 1,290 | 1,628 | 46.11 | 4.37 | 9,996 |
| **IGCC**[24] | 550 | 1,350 | 1,785 | 61.3 | 0.98 | 9,000 |
| **Nuclear** | 1,000 | 1,957 | 2,352 | 69.93 | 0.55 | 10,400 |
| **Combined Cycle** | 500 | 440 | 529 | 5.57 | 2.19 | 7,200 |
| **Combustion Turbine** | 160 | 375 | 425 | 2.19 | 3.82 | 10,450 |

## 3.2 Energy Efficiency Data

The 21st CEP Energy Efficiency Workgroup ("EEW") considered two alternative energy efficiency programs in their studies. The energy efficiency cases included in this Study parallel the 21st CEP EEW cases. Case EE1 is premised on a low penetration energy efficiency program with low energy reductions and high costs. Reductions in energy consumption resulting from energy efficiency programs were modeled to cost an average of 5.5¢/kWh for Case EE1. As can be seen in Table 3.4, the energy and demand reductions for Case EE1 are almost half that of Case EE2. Case EE2 is based on a moderate penetration energy efficiency program with higher reductions in energy consumption and lower costs. This case is more representative of energy efficiency program experience found in other states. Reductions in energy consumption resulting from energy efficiency programs were modeled to cost an average of 2.7¢/kWh for Case EE2.

**Table 3.4 – Energy Efficiency Cases Consumption & Demand Reductions**

| | LOW PENETRATION CASE EE1 | | | | HIGH PENETRATION CASE EE2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Energy Reduction - (GWh) | | | Peak Reduction (MW) | Energy Reduction - (GWh) | | | Peak Reduction (MW) |
| | Residential | Commercial | Total | | Residential | Commercial | Total | |
| **2007** | 204 | 225 | 429 | 348 | 381 | 359 | 740 | 383 |
| **2008** | 407 | 446 | 853 | 434 | 763 | 720 | 1,483 | 516 |
| **2009** | 612 | 674 | 1,286 | 522 | 1,149 | 1,087 | 2,236 | 651 |
| **2010** | 817 | 897 | 1,714 | 607 | 1,533 | 1,449 | 2,982 | 784 |
| **2011** | 1,023 | 1,126 | 2,149 | 695 | 1,921 | 1,819 | 3,740 | 919 |
| **2012** | 1,231 | 1,353 | 2,584 | 783 | 2,311 | 2,191 | 4,502 | 1,056 |
| **2013** | 1,437 | 1,578 | 3,015 | 870 | 2,699 | 2,559 | 5,258 | 1,190 |
| **2014** | 1,644 | 1,808 | 3,452 | 959 | 3,086 | 2,929 | 6,015 | 1,325 |
| **2015** | 1,852 | 2,037 | 3,889 | 1,047 | 3,472 | 3,292 | 6,764 | 1,460 |
| **2016** | 2,056 | 2,261 | 4,317 | 1,134 | 3,854 | 3,643 | 7,497 | 1,591 |
| **2017** | 2,261 | 2,480 | 4,741 | 1,219 | 4,237 | 3,994 | 8,231 | 1,721 |
| **2018** | 2,465 | 2,701 | 5,166 | 1,306 | 4,620 | 4,350 | 8,970 | 1,853 |
| **2019** | 2,667 | 2,918 | 5,585 | 1,390 | 5,004 | 4,702 | 9,706 | 1,984 |
| **2020** | 2,876 | 3,140 | 6,016 | 1,477 | 5,393 | 5,062 | 10,455 | 2,117 |
| **2021** | 3,085 | 3,372 | 6,457 | 1,565 | 5,785 | 5,430 | 11,215 | 2,252 |
| **2022** | 3,297 | 3,603 | 6,900 | 1,654 | 6,179 | 5,804 | 11,983 | 2,389 |
| **2023** | 3,507 | 3,837 | 7,344 | 1,743 | 6,575 | 6,184 | 12,759 | 2,528 |
| **2024** | 3,720 | 4,070 | 7,790 | 1,834 | 6,980 | 6,577 | 13,557 | 2,670 |
| **2025** | 3,913 | 4,266 | 8,179 | 1,912 | 7,364 | 6,933 | 14,297 | 2,802 |

Table 3.4 shows the energy and demand reductions from the Base Case electric consumption for Cases EE1 and EE2. The reductions shown in Table 3.4 are the

[24] Integrated Gasification Combined Cycle.

reductions in electric consumption at the meter. The actual reductions in electric GWh produced and reduced MW demand is approximately 9.5% higher than these figures due to electric line losses through the distribution and transmission system. The generation supply additions for Cases EE1 and EE2 were assumed to be provided only from conventional generation sources. Thus, only existing renewable energy generation was included in Cases EE1 and EE2.

## *3.3 Renewable Energy Data*

The data used in modeling the RPS cases was based upon the work of the Renewables Work Group ("RWG") of the 21st CEP. The low RPS Case (RPS1) is based upon the 21st CEP RWG modeling of 7% renewables by 2015[25]. The mix of generation resources for Case RPS1 is shown in Table 3.5. The RPS target of 7% was set for the end of 2015. The full generation output of the renewable generation sources was not reached until 2016 for Case RPS1.

**Table 3.5 - Low RPS (RPS1) Generation Mix (GWh)**

| | Anaerobic Digestion | Landfill Gas | Wind | Waste | Hydro | Biomass | TOTAL | Percent Renewable |
|---|---|---|---|---|---|---|---|---|
| 2006 | 0 | 0 | 4 | 1,573 | 1,702 | 0 | 3,279 | 3.0% |
| 2007 | 28 | 190 | 29 | 1,573 | 1,702 | 0 | 3,521 | 3.1% |
| 2008 | 75 | 371 | 218 | 1,573 | 1,702 | 284 | 4,223 | 3.7% |
| 2009 | 124 | 561 | 221 | 1,573 | 1,702 | 569 | 4,749 | 4.1% |
| 2010 | 166 | 743 | 297 | 1,573 | 1,702 | 853 | 5,333 | 4.6% |
| 2011 | 208 | 932 | 383 | 1,573 | 1,702 | 1,136 | 5,934 | 5.0% |
| 2012 | 305 | 948 | 673 | 1,573 | 1,702 | 1,449 | 6,650 | 5.5% |
| 2013 | 374 | 972 | 889 | 1,573 | 1,702 | 1,761 | 7,271 | 5.9% |
| 2014 | 450 | 996 | 1,012 | 1,573 | 1,702 | 2,074 | 7,806 | 6.3% |
| 2015 | 512 | 1,011 | 1,148 | 1,573 | 1,702 | 2,386 | 8,332 | 6.6% |
| 2016 | 575 | 1,035 | 1,295 | 1,573 | 1,702 | 2,699 | 8,878 | 7.0% |
| 2017 | 585 | 1,059 | 1,319 | 1,573 | 1,702 | 2,749 | 8,987 | 7.1% |
| 2018 | 598 | 1,075 | 1,347 | 1,573 | 1,702 | 2,808 | 9,102 | 7.1% |
| 2019 | 611 | 1,098 | 1,378 | 1,573 | 1,702 | 2,872 | 9,233 | 7.1% |
| 2020 | 625 | 1,122 | 1,409 | 1,573 | 1,702 | 2,938 | 9,369 | 7.1% |
| 2021 | 638 | 1,146 | 1,438 | 1,573 | 1,702 | 2,997 | 9,493 | 7.1% |
| 2022 | 651 | 1,162 | 1,468 | 1,573 | 1,702 | 3,060 | 9,615 | 7.0% |
| 2023 | 666 | 1,185 | 1,501 | 1,573 | 1,702 | 3,128 | 9,754 | 7.1% |
| 2024 | 681 | 1,209 | 1,534 | 1,573 | 1,702 | 3,198 | 9,896 | 7.1% |
| 2025 | 694 | 1,225 | 1,564 | 1,573 | 1,702 | 3,262 | 10,019 | 7.0% |

The moderate RPS case (RPS2) assumed the RPS target was increased to 15% by 2025. This case assumed that all additional renewable resources above the 7% level are provided by wind power. Table 3.6 shows the RPS mix used in Case RPS2 model with the 15% target being reached in 2025. Wind power projects were modeled with a 28% capacity factor and a 12% contribution to utility capacity requirements for meeting reserve margins. Neither Case RPS1 nor RPS2 included any increases in hydro or waste generation sources. Solar power additions were negligible. Electric consumption in

[25] See discussion on page 122 & 123 of Appendix II of the 21st Century Electric Energy Plan.

Cases RPS1 and RPS2 did not include any impacts due to energy efficiency beyond those assumed in the Base Case.

**Table 3.6 - Moderate RPS (RPS2) Generation Mix (GWh)**

| | Anaerobic Digestion | Landfill Gas | Waste | Base Hydro | Biomass | Wind | TOTAL | Percent Renewable |
|---|---|---|---|---|---|---|---|---|
| **2006** | 0 | 0 | 1,573 | 1,702 | 0 | 4 | 3,279 | 3.0% |
| **2007** | 28 | 190 | 1,573 | 1,702 | 0 | 29 | 3,521 | 3.1% |
| **2008** | 75 | 371 | 1,573 | 1,702 | 284 | 218 | 4,223 | 3.7% |
| **2009** | 124 | 561 | 1,573 | 1,702 | 569 | 221 | 4,749 | 4.1% |
| **2010** | 166 | 743 | 1,573 | 1,702 | 853 | 297 | 5,333 | 4.6% |
| **2011** | 208 | 932 | 1,573 | 1,702 | 1,136 | 383 | 5,934 | 5.0% |
| **2012** | 305 | 948 | 1,573 | 1,702 | 1,449 | 673 | 6,650 | 5.5% |
| **2013** | 374 | 972 | 1,573 | 1,702 | 1,761 | 889 | 7,271 | 5.9% |
| **2014** | 450 | 996 | 1,573 | 1,702 | 2,074 | 1,012 | 7,806 | 6.3% |
| **2015** | 512 | 1,011 | 1,573 | 1,702 | 2,386 | 1,148 | 8,332 | 6.6% |
| **2016** | 575 | 1,035 | 1,573 | 1,702 | 2,699 | 1,295 | 8,878 | 7.0% |
| **2017** | 585 | 1,059 | 1,573 | 1,702 | 2,749 | 2,397 | 10,065 | 7.9% |
| **2018** | 598 | 1,075 | 1,573 | 1,702 | 2,808 | 3,605 | 11,360 | 8.8% |
| **2019** | 611 | 1,098 | 1,573 | 1,702 | 2,872 | 4,847 | 12,702 | 9.7% |
| **2020** | 625 | 1,122 | 1,573 | 1,702 | 2,938 | 6,126 | 14,085 | 10.7% |
| **2021** | 638 | 1,146 | 1,573 | 1,702 | 2,997 | 7,482 | 15,538 | 11.6% |
| **2022** | 651 | 1,162 | 1,573 | 1,702 | 3,060 | 8,847 | 16,994 | 12.5% |
| **2023** | 666 | 1,185 | 1,573 | 1,702 | 3,128 | 10,231 | 18,485 | 13.4% |
| **2024** | 681 | 1,209 | 1,573 | 1,702 | 3,198 | 11,672 | 20,034 | 14.3% |
| **2025** | 694 | 1,225 | 1,573 | 1,702 | 3,262 | 13,176 | 21,631 | 15.3% |

## 3.4 Combined Energy Efficiency and RPS Cases

These cases combined the impacts of the energy efficiency case with the RPS case. Electric sales levels for the combined cases were set identical to the sales level of the respective energy efficiency case. The generation supply mix was set such that the amount of renewable generation needed in the respective RPS case was used in the combined case. Any reduction in the need for new generation resulting from decreased electric load from energy efficiency resulted in a reduction of need for conventional fossil generation. For example, in case EE2-RPS2, the sales were taken from Case EE2 and the amount of renewable generation was taken from Case RPS2 to produce the combined case. This results in RPS levels slightly higher then those of the respective RPS cases.

## 3.5 RPS Cases with Michigan Manufacturing of Components

As discussed earlier, two cases, Case RPS1-Wind and Case RPS2-Wind, were modeled to assess the impact on Michigan’s economy if the State were to attract renewable energy manufacturing. The modeling of Cases RPS1-Wind and RPS2-Wind were modeled in ENERGY 2020 identically to Cases RPS1 and RPS2. The generation mix, costs and electric sales were all identical to the respective RPS cases. The changes in modeling were made in the REMI capital cost allocation factors for renewable energy component costs. These factors were adjusted to reflect that all the manufacturing costs of wind generation components were provided by Michigan industry. In the RPS cases, wind component manufacturing assumed a Michigan content of approximately 8%. In the

RPS-Wind cases, the Michigan manufacturing content level was raised to 100% for both Cases RPS1-Wind and RPS2-Wind.

## *3.6 REMI Assumptions*

As discussed earlier, the REMI model was used to analyze the economic impacts on Michigan of the changes in energy efficiency and RPS policies. The base parameters contained in the REMI model were used for all model runs because they already incorporated the data associated with Michigan's economy. Since this Study's focus is on how the changes in electric generation affect Michigan's economy, certain of REMI's parameters were adjusted to better represent electric only stimulation of Michigan's economy. The REMI factors adjusted for this Study were the allocation of capital investments, fuel costs and operating & maintenance (O&M) costs associated with power generation and the utility sector. Tables O, P, Q, and R in Appendix D contains the REMI input fractions for cost allocation used in the REMI modeling for this Study. The base REMI model would normally allocate changes in investments and operating costs in accordance with the distribution of these costs in the general economy. This would have improperly allocated costs generated in the utility sector for new plant investment, O&M costs and fuel costs, across all other sectors of Michigan's economy. For the purpose of this study, the allocation of capital investment, O&M costs, fuel costs, etc, associated with new capacity and energy, were allocated only to the appropriate REMI categories. The allocation was developed based upon factors contained in utility Reports to the MPSC in MPSC Form P-521, other industry data sources and industry experience.

## *3.7 Model Reporting Horizon*

Construction of new generation was modeled to occur over a multi-year period ranging from two years for new wind generation to six years for new coal fired generation. As Michigan's electric load grows, ENERGY 2020 selects the most economical generation source to ensure sufficient generation is available to meet the load conditions. Base load coal power plants are added in the year when load growth reaches the point that utilization of the plant proves to be economical. Energy 2020 will initiate plant construction prior to the year the plant is needed to serve load.

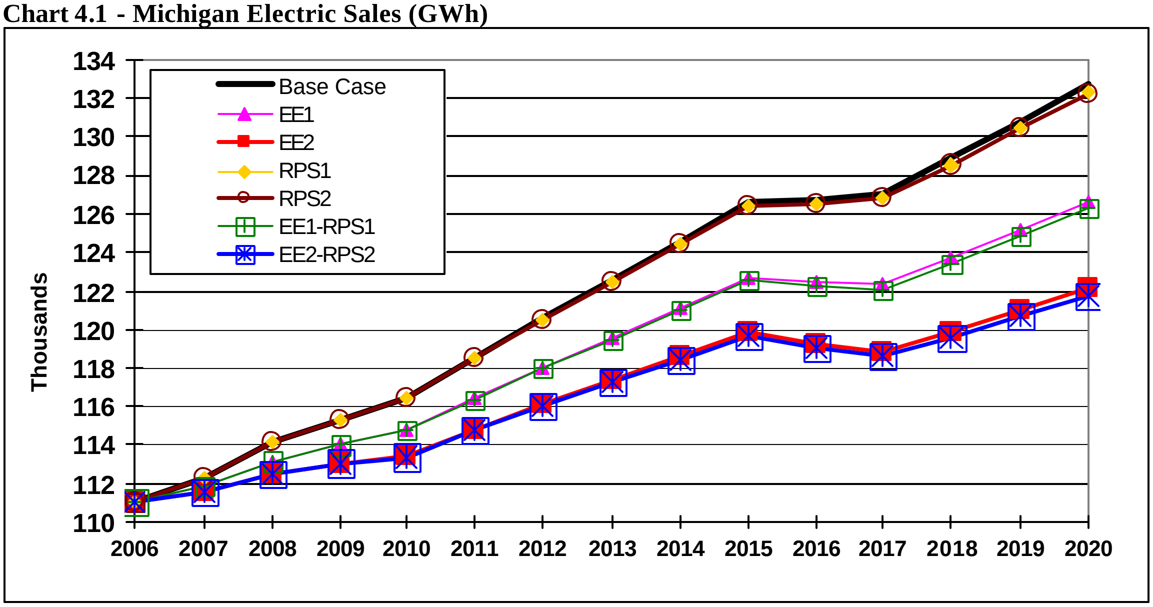
The termination of the Study modeling at the end of 2025 impacted how new power plant construction occurs prior to 2025. If Michigan's load growth would require a new power plant in 2026, the new power plant would not be included in the modeled construction for this Study. This had an impact on the model results in the last five years of the Study. Upon review of the results, it was discovered that toward the end of the modeling period some of the results did not follow construction modeling result trends contained in prior year results. Detailed review found the modeling was impacted by the termination of the modeling in 2025. As such, it was decided that the results to be included in this report will only be up through the end of 2020 to eliminate the construction cycle modeling differences in later years. All data used in the modeling process of this Study included the full modeling period of 2006 through 2025. However, the reported results represent the period through the end of 2020.

# 4 Electric Supply Results

## *4.1 Electricity Generation*

The projected electric sales (in GWh) for each of the cases is shown in Chart 4.1. Electric sales for RPS1 and RPS2 are virtually identical to the Base Case, but are slightly different due to RPS impacts on Michigan's economy. The similarity between the Base Case and Cases RPS1 and RPS2 is expected since the total load required for the renewable generation cases does not change; only the mix of generation sources change. The energy efficiency cases and the combined energy efficiency/RPS cases both exhibit reduced electric sales resulting from the effective implementation of customer energy efficiency measures. Electric sales are reduced by over 4.5% by 2020 in the low penetration energy efficiency case, EE1. Electric sales are reduced by over 7.9% by 2020 in the moderate penetration energy efficiency case, EE2. Similar results are seen in the combined energy efficiency and RPS cases, cases RPS1-EE1 and RPS2-EE2, as were found in cases EE1 and EE2.

**Chart 4.1 - Michigan Electric Sales (GWh)**




### 4.1.1 Energy Efficiency Cases

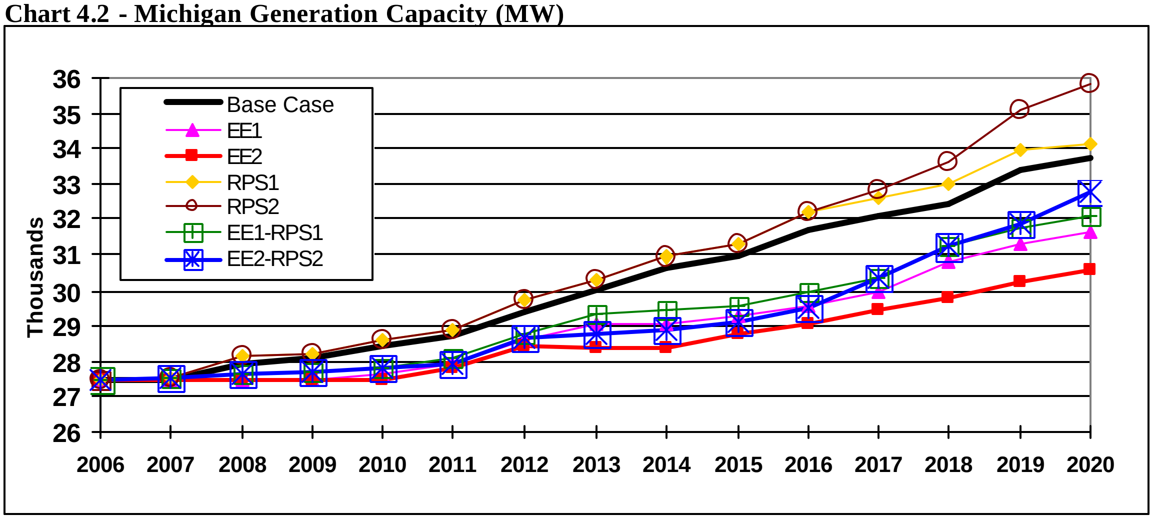
The expected total installed generation capacity (in MW) is shown in Chart 4.2. As expected, decreased electric consumption and demand reduced the amount of installed capacity for the energy efficiency cases. In the low penetration energy efficiency case, EE1, installed generation capacity is 6.4% lower for year 2020 than the Base Case. In the moderate penetration energy efficiency case, EE2, installed generation capacity drops even more, with the models showing a 9.7% reduction over year 2020 Base Case.

### 4.1.2 RPS Cases

In the renewable cases, the models show an increase in the amount of installed capacity. The increased capacity is caused by the contribution to reserve margin set for renewable generation, specifically that of wind generation. Consistent with the 21st CEP, wind was also modeled to produce power at the level equivalent to operating only 28% of the hours in a year, or a capacity factor of 28%. The contribution toward utility capacity for wind projects was set at 12%. The difference in contribution between wind generation and fossil fuel generation causes ENERGY 2020 to add additional capacity to ensure utility reserve margins are met. For each MW of wind generation added, ENERGY 2020 modeled a 0.12 MW contribution toward system peak. If the RPS target calls for 100 MW of wind generation and the utility reserve margin also requires 100 MW of new capacity, then ENERGY 2020 will add 100 MW of wind generation and 88 MW of generation from other sources. The added 88 MW of other generation is added because only 12 MW of the wind generation is counted as contributing to required reserve margins.

However, recent Michigan wind data and modeling of wind conditions at higher elevations suggest that the capacity factor for wind generation is likely closer to 32%. For the low RPS case, RPS1, the increase in installed generation capacity is approximately 1.19% in year 2020 over the Base Case. The moderate RPS case, RPS2, shows the increase in installed generation capacity to be 13.25% in year 2020 over the Base Case. The higher installed generation capacity for Case RPS2 is due to the assumption that all renewable additions above 7% RPS level will be supplied by wind power, and the setting of wind capacity factor is at 28%, and contribution to peak was set at only 12% of installed wind generation capacity. Wind power's contribution to peak and capacity factor causes the need to install the additional capacity.

**Chart 4.2 - Michigan Generation Capacity (MW)**



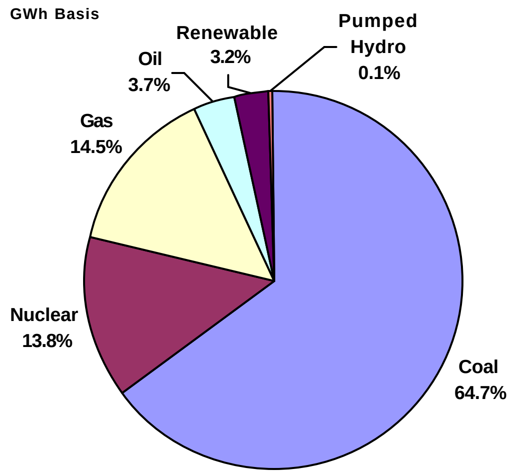

## 4.2 Generation Mix

The following series of charts depict the mix of generation types supplying Michigan's electricity load and the change over time for each case.

### 4.2.1 Base Case

The base 2006 generation mix is shown in Chart 4.3, representing the current power generation mix in the state of Michigan – approximately 65% coal, 14% nuclear, 18% gas and oil and only 3% renewables. This chart is based upon the amount of GWh produced from each fuel source. In the absence of RPS and

**Chart 4.3 - 2006 Generation Mix**




energy efficiency policies (Base Case), the ENERGY 2020 model projects that the power generations mix will change only slightly by 2015, as shown in Chart 4.4. Coal's share will increase to represent almost 71% of generation, primarily due to the development of new base load pulverized coal power plants. Natural gas's & oil's share is reduced slightly to 13%, while renewables drop to 3% in

**Chart 4.4 - Base Case 2015 Generation Mix**

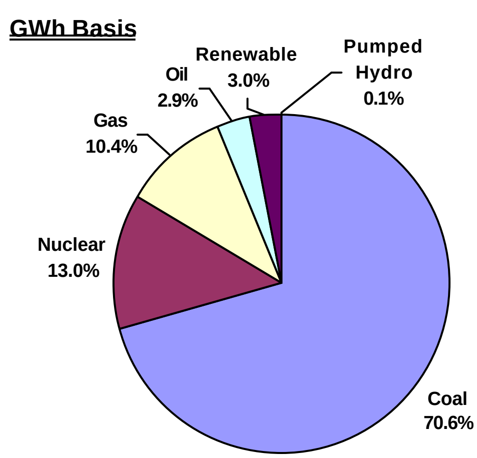
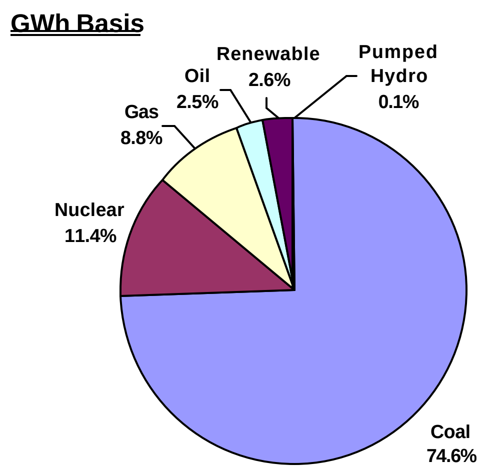



**Chart 4.5 - Base Case 2020 Generation Mix**




2015. By 2020, the Base Case generation mix is projected to be 74.6% coal, 11.4% nuclear, less than 12% oil & natural gas, and renewables drop to 2.6%, as shown in Chart 4.5. The share of coal use increases due to the lower operating costs of coal projects. Additional natural gas generation or combustion turbine & combined cycle, is added to the mix, as seen in Table 3.2, but it is mostly peaking capacity which is seldom used.

### 4.2.2 Low Penetration Energy Efficiency Case EE1

In the low penetration energy efficiency case, the ENERGY 2020 model projects that the power generation mixes will change slightly by 2015 and 2020 relative to the Base Case, as shown in Chart 4.6 and Chart 4.7. Coal continues to be the dominant energy source with 70.9% share in 2015 and 74.8% share in 2020. The

**Chart 4.6 - Case EE1 2015 Generation Mix**

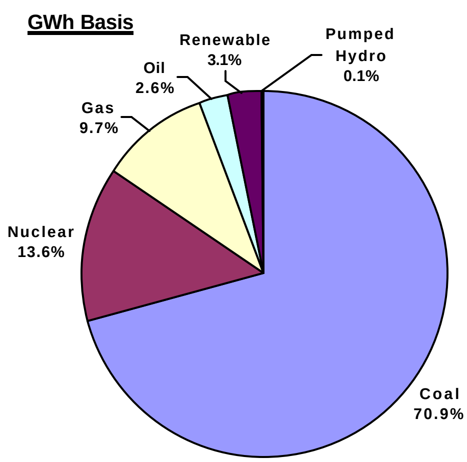
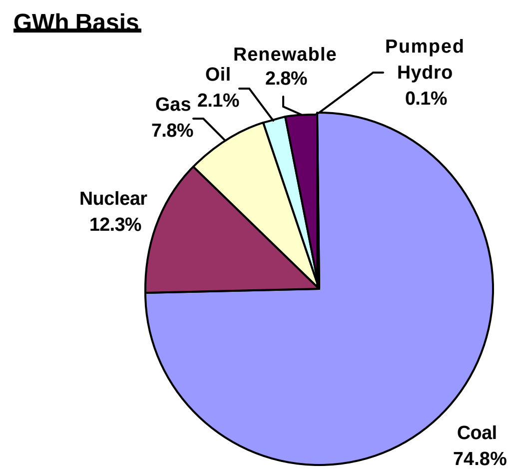



**Chart 4.7 - Case EE1 2020 Generation Mix**




impact of the demand side management programs can be seen in the reduction of peaking generation. Oil & gas generation's share of production drops to 12.3% in 2015 and 9.9% in 2020. Nuclear and renewables remain relatively constant.

### 4.2.3 Moderate Penetration Energy Efficiency Case EE2

In the moderate penetration energy efficiency case, the ENERGY 2020 model projects that the power generation mixes will change slightly by 2015 and 2020 relative to the Base Case, as shown in Chart 4.8 and Chart 4.9. The changes in generation mix are similar to Case EE1. The impact of the additional energy efficiency can be seen in the reduction in coal share of GWh generated. Coal produced electricity drops in 2020 by 1.5% from the Base Case and 1.7% from Case EE1. Surprisingly, the relative share of natural gas & oil production increase in 2020, due to the change in the load shape that is caused by the energy efficiency programs.

**Chart 4.8 - Case EE2 2015 Generation Mix**

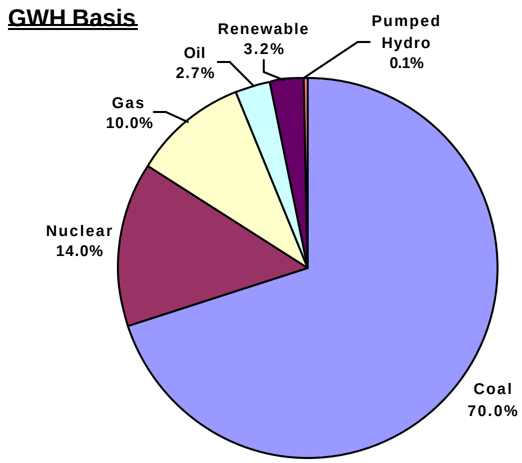
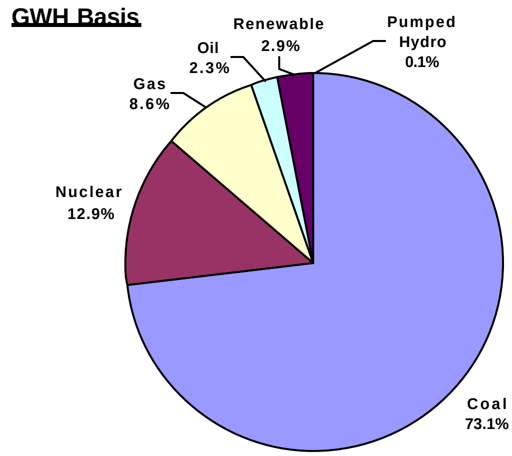



**Chart 4.9 - Case EE2 2020 Generation Mix**




### 4.2.4 Low RPS Case RPS1

In the low RPS case, ENERGY 2020 model results show a more significant changes in the power generation mix. As expected, renewables increase to approximately 7% of the total GWh produced by 2015 and maintain it through 2020. Chart 4.10 shows that the coal share of GWh produced drops to 69% in 2015 and Chart 4.11 shows coal share down to 70.7% in 2020. Gas & oil generation in 2015 drop only moderately to 10.8%.

**Chart 4.10 - Case RPS1 2015 Generation Mix**

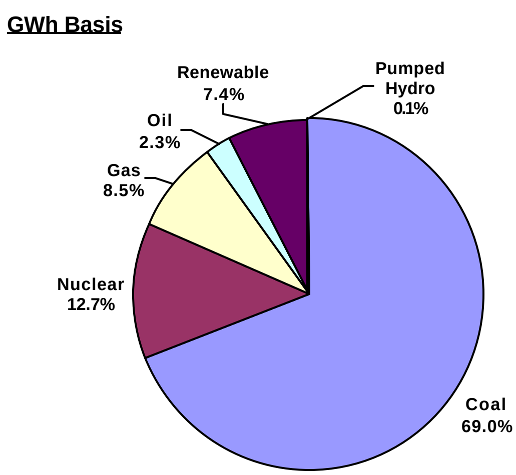
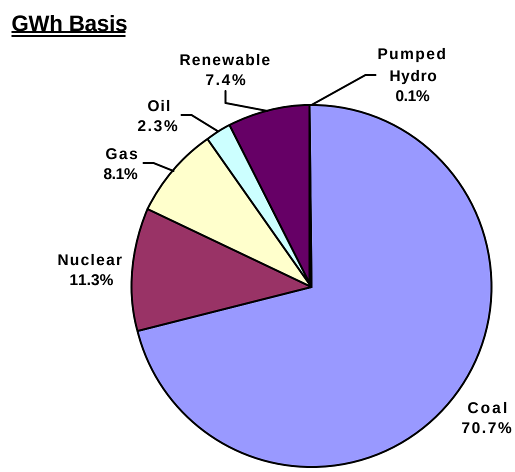



**Chart 4.11 - Case RPS1 2020 Generation Mix**




In 2020, natural gas, oil and nuclear generation shares are similar to the Base Case.

### 4.2.5 Moderate RPS Case RPS2

The results for Case RPS2 are identical to those of Case RPS1 in 2015, as shown in Chart 4.12. By 2020, renewables have increased their share of generation to 11%, as seen in Chart 4.13. Coal generation share in 2020 has dropped 6.6%

from the Base Case. Oil & gas generation's share drops to less than 10% in 2020. Nuclear generation share remains approximately the same as in the 2020 Base Case.

**Chart 4.12 - Case RPS2 2015 Generation Mix**

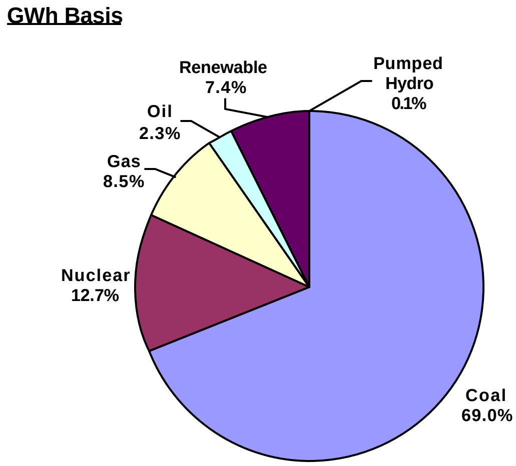
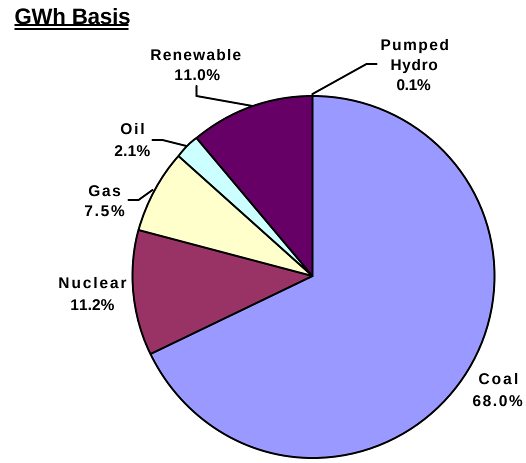



**Chart 4.13 - Case RPS2 2020 Generation Mix**




### 4.2.6 Combined Low penetration Energy Efficiency & RPS Case EE1-RPS1

In the low penetration combined case, Case EE1-RPS1, ENERGY 2020 modeling indicates significant changes in fossil generation. In 2015, the combined implementation of energy efficiency and RPS could drop fossil generation by 5.2% from the Base Case, as shown in Chart 4.14. Renewables share of power generation mix is up to 7.7% in 2015. In 2020, the fossil share of the generation mix shown in Chart 4.15 is 6.0% lower than the Base Case. The coal share of the

**Chart 4.14 - Case EE1-RPS1 2015 Generation Mix**

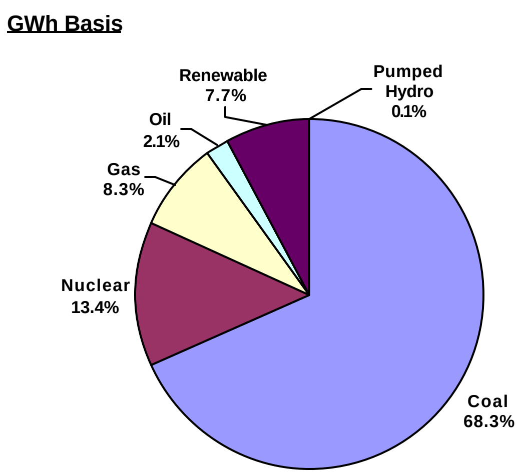
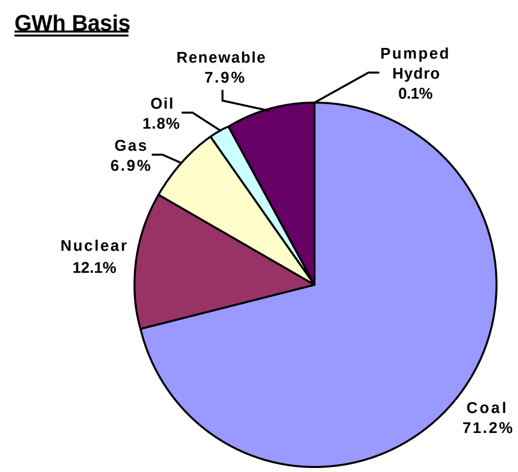



**Chart 4.15 - Case EE1-RPS1 2020 Generation Mix**




generation mix is also lower then the coal share in Case EE1, by over 3% in 2020. The results of Case EE1-RPS1 shows that the combined energy efficiency and RPS will reduce fossil generation share of the power generation mix more than either energy efficiency programs or RPS could provide independently of each other.

### 4.2.7 Combined Moderate Penetration Energy Efficiency & RPS Case EE2-RPS2

The power generation mix for the combined moderate Case EE2-RPS2 reduces fossil fuel portion of the generation mix even more than the combined Case EE1-RPS1. As shown in Chart 4.16, fossil's generation share in 2015 drops to 78% in Case EE2-RPS2 as compared to 83.9% in the Base Case. By 2020, renewable generation has risen to 12.4% share of the generation mix, as shown in Chart 4.17. In 2020, coal's generation share is reduced from the Base Case by 9.4% for Case EE2-RPS2.

**Chart 4.16- Case EE2-RPS2 2015 Generation Mix**

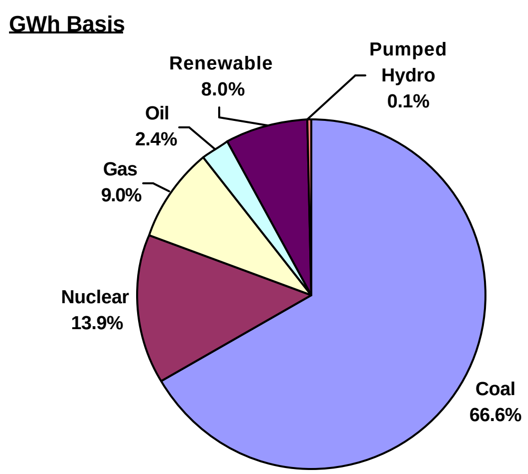
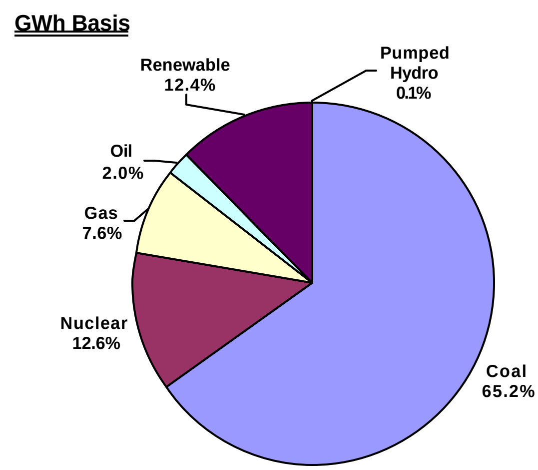


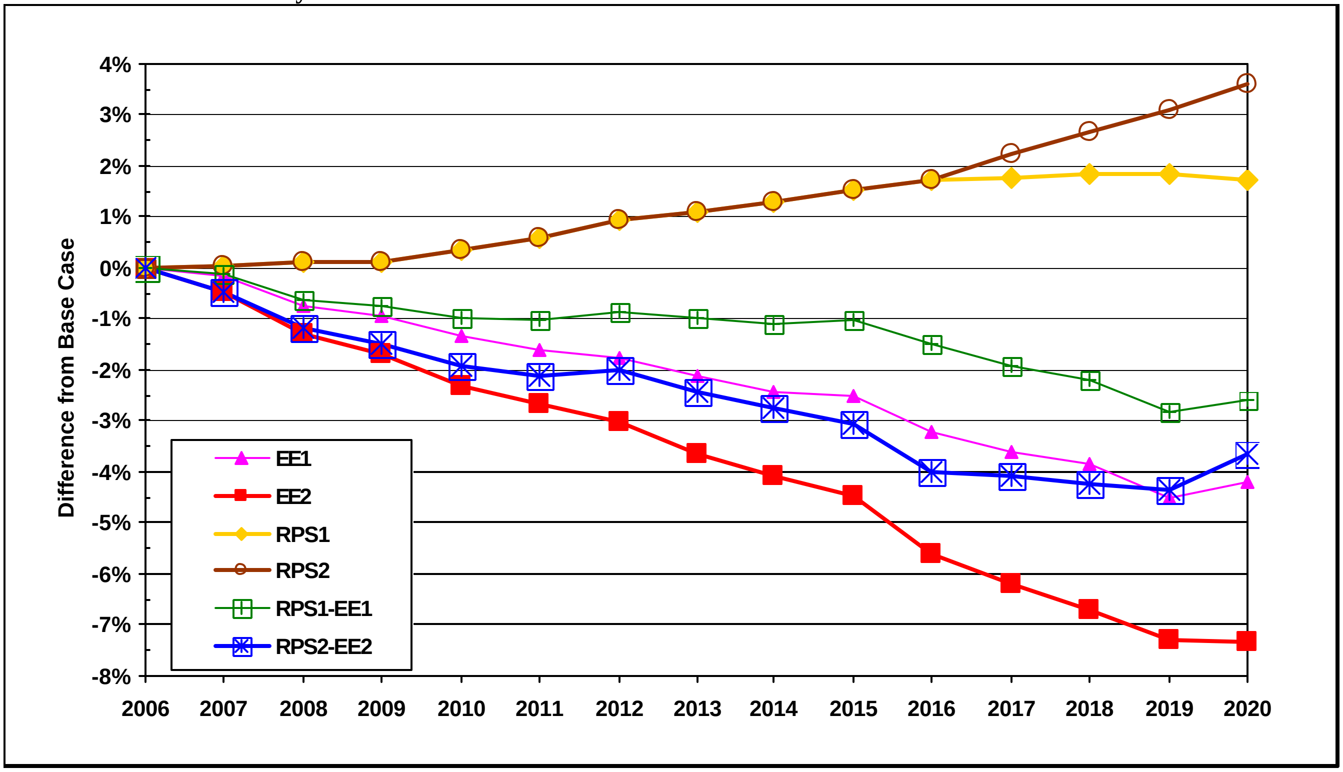

**Chart 4.17- Case EE2-RPS2 2020 Generation Mix**




## *4.3 Electricity Costs*

The difference in total annual utility revenue requirement from the Base Case is shown in Chart 4.18. ENERGY 2020 produces the total annual utility revenue requirement based upon the amount a utility can expect to collect from its customers. The build up of revenue requirement includes costs from operations & maintenance ("O&M"), fuel, purchase power, transmission charges, return on capital investment and recovery of that investment. Changes in any of these categories of costs will change the utility revenue requirement. The primary cost changes in these models will be in fuel, O&M costs and capital cost recovery. Chart 4.18 shows the changes from the Base Case that each of the policy cases will cause on total utility revenue requirement. This is representative of the rate impacts on customers because electric rates are designed to recover the total cost a utility incurs. The following sections discuss the Study's findings for each of the policy cases and the data represented in Chart 4.18.

**Chart 4.18 - Annual Utility Revenue Difference from Base Case**




### 4.3.1 Energy Efficiency Cases

**Table 4.1 - Utility Revenue Difference from Base Case**

| | 2010 | | 2015 | | 2020 | |
|---|---|---|---|---|---|---|
| **CASE EE1** | | | | | | |
| Residential | $77 | 2.2% | $165 | 4.7% | $275 | 7.6% |
| Commercial | $41 | 0.9% | $81 | 1.5% | $161 | 2.7% |
| Industrial | $20 | 0.9% | $38 | 1.6% | $74 | 2.8% |
| Total | $139 | 1.3% | $284 | 2.5% | $510 | 4.2% |
| **CASE EE2** | | | | | | |
| Residential | $144 | 4.2% | $314 | 9.0% | $518 | 14.3% |
| Commercial | $65 | 1.4% | $130 | 2.4% | $252 | 4.3% |
| Industrial | $32 | 1.4% | $62 | 2.5% | $117 | 4.4% |
| Total | $241 | 2.3% | $506 | 4.5% | $887 | 7.3% |
| **CASE RPS1** | | | | | | |
| Residential | ($3) | (0.1%) | ($37) | (1.1%) | ($54) | (1.5%) |
| Commercial | ($24) | (0.5%) | ($95) | (1.8%) | ($108) | (1.8%) |
| Industrial | ($11) | (0.5%) | ($41) | (1.7%) | ($48) | (1.8%) |
| Total | ($38) | (0.4%) | ($174) | (1.5%) | ($211) | (1.7%) |
| **CASE RPS2** | | | | | | |
| Residential | ($3) | (0.1%) | ($37) | (1.1%) | ($94) | (2.6%) |
| Commercial | ($24) | (0.5%) | ($95) | (1.8%) | ($239) | (4.1%) |
| Industrial | ($11) | (0.5%) | ($41) | (1.7%) | ($107) | (4.0%) |
| Total | ($38) | (0.4%) | ($174) | (1.5%) | ($440) | (3.6%) |
| **CASE EE1-RPS1** | | | | | | |
| Residential | $71 | 2.1% | $127 | 3.6% | $228 | 6.3% |
| Commercial | $20 | 0.4% | ($10) | (0.2%) | $58 | 1.0% |
| Industrial | $11 | 0.5% | ($1) | (0.1%) | $28 | 1.1% |
| Total | $102 | 1.0% | $116 | 1.0% | $314 | 2.6% |
| **CASE EE2-RPS2** | | | | | | |
| Residential | $138 | 4.0% | $277 | 7.9% | $436 | 12.0% |
| Commercial | $39 | 0.8% | $43 | 0.8% | $0 | 0.0% |
| Industrial | $20 | 0.9% | $24 | 1.0% | $4 | 0.2% |
| Total | $198 | 1.9% | $344 | 3.1% | $441 | 3.6% |

Total utility revenue requirement is projected to decrease from the Base Case in the energy efficiency cases. The reduction in utility revenue requirement for case EE1 is projected to be about 4.3% by 2020. The primary cause of this reduction in utility revenue requirement is the elimination of the need for over 2,100 MW (1,000 MW of coal) of new generation in 2020. Total GWh generated, as shown in Chart 4.1, is over 6,000 GWh less for Case EE1 than for the Base Case. The reduction in generation capacity and electric consumption accounts for the lower utility revenue requirement. This lower utility revenue requirement causes the estimated reductions in utility costs for the various customer classes shown in Table 4.1. Residential electric rates could decrease by 7.6% from the projected Base Case levels by 2020 by implementation of the energy efficiency program modeled inc Case EE1.

The reduction in total utility revenue requirement from that of the Base Case is even greater for Case EE2. Utility revenue requirement is projected by ENERGY 2020 to decrease from the Base Case by over 7.3% with the implementation of the energy efficiency programs modeled in Case EE2. This represents an $887 million reduction in 2020 utility revenue requirement. As with Case EE1, the reduction in utility costs is due to reduced capacity additions and lower generation production. The energy efficiency measures of Case EE2 are projected to reduce the required 2020 fossil generation plant capacity by over 3,100 MW (2,000 MW of coal) from the projected Base Case requirements. This represents the elimination of four 500 MW coal plants. Electric generation decreases by over 10,500 GWh in 2020 from that of the Base Case with the energy efficiency programs of Case EE2. This all translates into reduced costs for all customer classes as shown in Table 4.1.

### 4.3.2 Renewable Portfolio Standard Cases

The 21st CEP and ENERGY 2020 both contain modeling parameters which cause the utility revenue requirement for scenarios with renewable energy to be higher then traditional utility generation resource plans. The two key parameters in the modeling that cause the higher utility revenue requirement are mainly associated with wind generation. Unlike traditional power generation resources, wind generation is an unpredictable source and cannot be scheduled for delivery at specific times. This reduces wind generation's value to maintaining electric system reliability and utility reserve margins. The value of a generation resource in meeting utility reserve margin is measured in its contribution to reserve margin. Traditional generation plants' reliability and predictability usually results in contribution to reserve margins in the range of 80% to 95% of plants' full load output. This is also usually the unit's capacity factor or percentage of full load output a power plant typically produces in a given year. Maintenance and outages caused by equipment failure prevent power plants from producing their full output for all hours in the year. The modeling in the 21st CEP and ENERGY 2020 included a wind capacity factor of 28% and a contribution to reserve margin of only 12% of the total installed wind generation capacity. As discussed earlier, this means that only 12 MW of every 100 MW of installed wind generation is counted toward reserve margin. The balance of reserve margin is made up by installing new fossil generation or purchasing power on the open market. The 28% capacity factor affects the amount of generation that is required from other generation sources.

Recent data for wind generation in Michigan indicate the capacity factor should be in the 32% range instead of 28%. This data is based upon wind conditions at higher altitude which is closer to the height of the current generation of wind turbines. A 4% increase in wind generation will cause a significant drop in purchase power or fossil fuel generation costs for both RPS cases.

Case RPS1 projected total utility revenue requirement increase over the Base Case peaks at 1.8% in 2018 and declines after that (see Chart 4.18). The steady increase in total utility revenue requirement is due to the build up of renewables to the RPS target of 7% in 2016. Total installed capacity is 402 MW higher under Case RPS1 then the Base Case in 2020 to account for the intermittency of wind. The benefits of lower fuel costs associated with renewable energy are not seen until after 2018. This trend will continue through the life of the renewable assets because fuel cost and O& M costs associated with fossil generation are higher then renewable generation. The primary costs for renewable generation is in the initial capital costs and the recovery of this cost will remain constant over the life of the generation resource. Fuel and O&M costs will continue to escalate for fossil generation sources. This will eventually result in a decrease in the costs for renewables from that of fossil generation and is seen in Case RPS1 after 2018.

Case RPS2 projected total utility revenue requirement continues to increase over the Base Case through 2020 because new renewable generation is being added until 2025. As a result we do not observe a period in which utility revenue requirements from renewable generation stabilize. Based on Case RPS1, it is likely that total utility revenue requirement will start to fall as compared to the Base Case after 2028.

## *4.4 Fossil Fuel Consumption*

Fossil fuel consumption (and associated emissions) drops significantly as a result of energy efficiency and RPS programs. Table 4.2 shows the amount of fossil fuels consumed in each case studied. As expected, the most significant effect results from the combined moderate penetration energy efficiency case and RPS implementation, which drops fossil fuel-produced GWh by over 20% in 2020. It is important to note that such fossil fuel savings and emissions benefits will occur far beyond the planning horizon of this study, resulting in a reduction in dollars flowing out of Michigan's economy for many years henceforth.

**Table 4.2 - Michigan Fossil Generation Fuel Consumption**

| | 2015 | | 2020 | |
|---|---|---|---|---|
| | Trillions of BTU per Year | Reduction from Base Case | Trillions of BTU per Year | Reduction from Base Case |
| Base Case | 1,042 | | 1,198 | |
| EE1 | 993 | 4.77% | 1,095 | 8.54% |
| EE2 | 967 | 7.27% | 1,050 | 12.33% |
| RPS1 | 1,011 | 2.98% | 1,144 | 4.48% |
| RPS2 | 1,011 | 2.98% | 1,106 | 7.66% |
| EE1-RPS1 | 955 | 8.40% | 1,046 | 12.68% |
| EE2-RPS2 | 921 | 11.69% | 957 | 20.10% |

# 5 Emissions

Emissions levels are highly dependent upon the fuel used and the type of control technology employed on the generation plant. This study takes into account the capital and operating costs associated with controlling regulated pollutants, consistent with the 21st Century Energy Plan assumptions. ENERGY 2020 provided the projections of $CO_2$ output shown in Table 5.1.

**Table 5.1 - Michigan CO2 Emissions**

| | BASE CASE | CASE EE1 | | | CASE EE2 | | | CASE RPS1 | | | CASE RPS2 | | | CASE EE1-RPS1 | | | CASE EE2-RPS2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TOTAL | TOTAL | Difference from Base Case | | TOTAL | Difference from Base Case | | TOTAL | Difference from Base Case | | TOTAL | Difference from Base Case | | TOTAL | Difference from Base Case | | TOTAL | Difference from Base Case | |
| | (ktons) | (ktons) | REDUCTION (ktons/Year) | PERCENT | (ktons) | REDUCTION (ktons/Year) | PERCENT | (ktons) | REDUCTION (ktons/Year) | PERCENT | (ktons) | REDUCTION (ktons/Year) | PERCENT | (ktons) | REDUCTION (ktons/Year) | PERCENT | (ktons) | REDUCTION (ktons/Year) | PERCENT |
| **2006** | 69,789 | 69,789 | 0 | 0.00% | 69,789 | 0 | 0.00% | 69,789 | 0 | 0.00% | 69,789 | 0 | 0.00% | 69,789 | 0 | 0.00% | 69,789 | 0 | 0.00% |
| **2007** | 69,328 | 69,268 | 60 | 0.09% | 69,254 | 74 | 0.11% | 69,308 | 20 | 0.03% | 69,308 | 20 | 0.03% | 69,248 | 79 | 0.11% | 69,234 | 94 | 0.14% |
| **2008** | 70,528 | 70,362 | 167 | 0.24% | 70,314 | 214 | 0.30% | 70,423 | 105 | 0.15% | 70,423 | 105 | 0.15% | 70,257 | 272 | 0.39% | 70,209 | 319 | 0.45% |
| **2009** | 72,573 | 72,339 | 234 | 0.32% | 72,259 | 313 | 0.43% | 72,393 | 179 | 0.25% | 72,393 | 179 | 0.25% | 72,162 | 410 | 0.57% | 72,083 | 489 | 0.67% |
| **2010** | 72,331 | 72,143 | 188 | 0.26% | 72,032 | 299 | 0.41% | 72,171 | 160 | 0.22% | 72,171 | 160 | 0.22% | 71,890 | 441 | 0.61% | 71,688 | 643 | 0.89% |
| **2011** | 74,886 | 73,169 | 1,716 | 2.29% | 72,743 | 2,143 | 2.86% | 74,245 | 640 | 0.86% | 74,245 | 640 | 0.86% | 72,456 | 2,430 | 3.24% | 72,055 | 2,830 | 3.78% |
| **2012** | 77,465 | 77,117 | 348 | 0.45% | 75,932 | 1,533 | 1.98% | 77,020 | 445 | 0.58% | 77,020 | 445 | 0.58% | 75,681 | 1,784 | 2.30% | 74,569 | 2,896 | 3.74% |
| **2013** | 79,871 | 78,418 | 1,452 | 1.82% | 76,449 | 3,422 | 4.28% | 78,982 | 889 | 1.11% | 78,982 | 889 | 1.11% | 77,315 | 2,556 | 3.20% | 74,637 | 5,233 | 6.55% |
| **2014** | 81,883 | 78,485 | 3,398 | 4.15% | 76,405 | 5,478 | 6.69% | 80,571 | 1,312 | 1.60% | 80,571 | 1,312 | 1.60% | 77,117 | 4,766 | 5.82% | 74,227 | 7,656 | 9.35% |
| **2015** | 83,259 | 79,944 | 3,315 | 3.98% | 77,815 | 5,444 | 6.54% | 81,719 | 1,541 | 1.85% | 81,719 | 1,541 | 1.85% | 77,643 | 5,617 | 6.75% | 74,673 | 8,586 | 10.31% |
| **2016** | 85,958 | 81,468 | 4,490 | 5.22% | 79,190 | 6,768 | 7.87% | 83,062 | 2,896 | 3.37% | 83,068 | 2,890 | 3.36% | 78,552 | 7,406 | 8.62% | 75,609 | 10,349 | 12.04% |
| **2017** | 87,406 | 83,508 | 3,897 | 4.46% | 80,944 | 6,462 | 7.39% | 84,549 | 2,857 | 3.27% | 83,636 | 3,770 | 4.31% | 79,632 | 7,774 | 8.89% | 76,514 | 10,891 | 12.46% |
| **2018** | 89,726 | 85,542 | 4,184 | 4.66% | 81,958 | 7,768 | 8.66% | 87,097 | 2,629 | 2.93% | 85,603 | 4,123 | 4.59% | 82,123 | 7,603 | 8.47% | 77,213 | 12,512 | 13.95% |
| **2019** | 92,960 | 87,038 | 5,923 | 6.37% | 83,298 | 9,663 | 10.39% | 90,058 | 2,903 | 3.12% | 87,991 | 4,969 | 5.35% | 83,988 | 8,973 | 9.65% | 76,974 | 15,986 | 17.20% |
| **2020** | 94,893 | 87,864 | 7,029 | 7.41% | 83,969 | 10,924 | 11.51% | 91,020 | 3,873 | 4.08% | 88,359 | 6,535 | 6.89% | 84,597 | 10,297 | 10.85% | 77,087 | 17,807 | 18.76% |

This table shows that $CO_2$ emissions are higher for the Base Case than every other case tested. By 2020, Base Case $CO_2$ emissions are about 7.0 million tons higher than Case EE1 and about 10.9 million tons higher for Case EE2. The energy efficiency Case EE1 is projected to reduce $CO_2$ emissions by over 3%. The energy efficiency Case EE2 is projected to reduce $CO_2$ emissions from electric generation by over 11.5%. Chart 5.1 shows the percent difference in

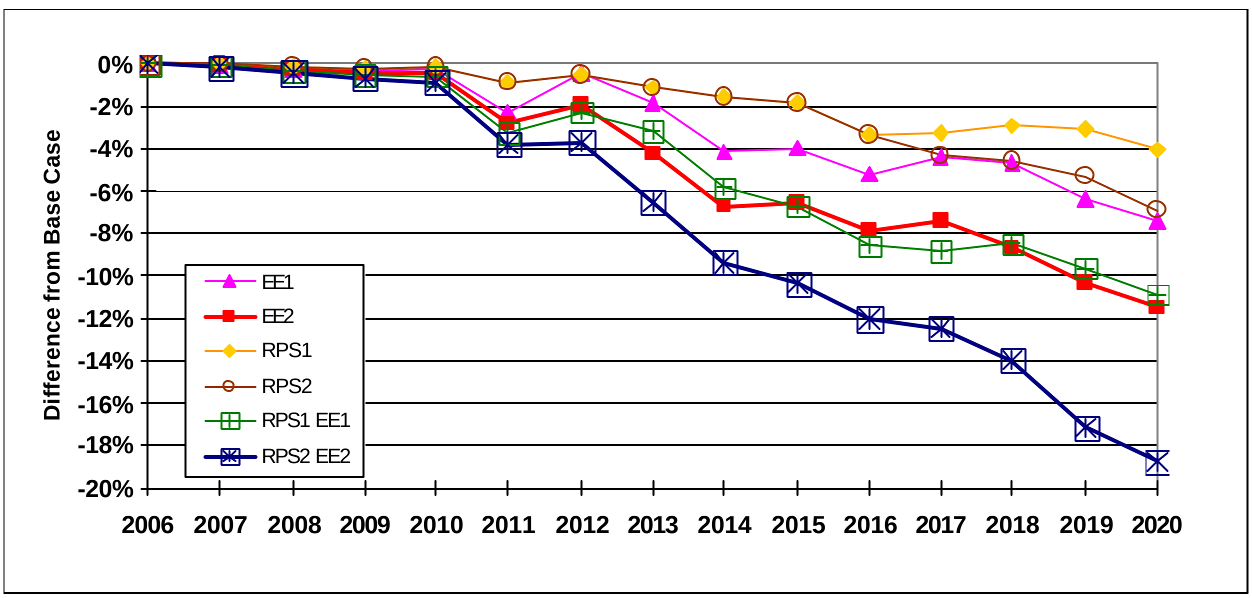



**Chart 5.1 - % Difference in Michigan CO2 Emissions from Base Case**

$CO_2$ emissions between each of the cases and the Base Case. For the RPS cases, the reduction in $CO_2$ emissions is also significant. RPS1 is projected to reduce $CO_2$ emissions in 2020 by over 3.8 million tons annually as compared to the Base Case. This is a reduction of over 4.0% in $CO_2$

emissions from electric generation. RPS2 is projected to reduce $CO_2$ emissions by a total of 6.5 million tons annually in 2020, as compared to the Base Case. This is almost a 6.9% reduction in electric generation $CO_2$ emissions.

The combined energy efficiency cases and RPS cases produced the most dramatic results. Case EE1-RPS1 is projected to reduce electric generation $CO_2$ emissions by almost 10.5% or 10.3 million tons annually, as compared to the Base Case. Case EE2-RPS2 shows the potential to reduce electric generation $CO_2$ emissions of over 18.7% in 2020. Total $CO_2$ emissions would be reduced in 2020 under EE2-RPS2 by a total of 17.8 million tons annually over that of the Base Case.

The value of $CO_2$ reduction can be approximated using today's carbon markets. $CO_2$ has traded as high as $4.20 per metric ton in the US carbon trading markets. The total amount of $CO_2$ reduction over the period between 2006 and 2020 for EE2 is approximately 60 million metric tons. Applying the value of $CO_2$ of $4.20 per metric ton to this amount equates to $253 million in today's market. Table 5.2 shows the value of the $CO_2$ reductions for each of the six primary cases modeled in this study versus the Base Case. This shows that the value of the $CO_2$ could be substantial should Michigan choose to enact these policies. The added financial benefit of the $CO_2$ credits for EE2-RPS2 equates to roughly $0.36/MWh for the period between 2007 and 2020 (2006 not included because of zero $CO_2$ reduction in that year).

**Table 5.2 - Value of Michigan's Potential CO2 Reductions**

| | Total CO2 Reduction from Base Case 2007 thru 2020 | | Value of CO2 at Todays Market Price |
|---|---|---|---|
| | millions of Metric Tons | Reduction | ($millions) |
| EE1 | 36.401 | 3.0% | $152.88 |
| EE2 | 60.506 | 5.0% | $254.12 |
| RPS1 | 20.448 | 1.7% | $85.88 |
| RPS2 | 27.578 | 2.3% | $115.83 |
| EE1-RPS1 | 60.406 | 5.0% | $253.71 |
| EE2-RPS2 | 96.294 | 8.0% | $404.43 |

For a more detailed analysis of the net economic impacts to Michigan's economy associated with the implementation of various greenhouse gas reduction strategies, see "Michigan at a Climate Crossroads", University of Michigan Center for Sustainable Systems, April 2007 (Report No. CSS07-02).

# 6 Michigan Economic Impact

The impact on Michigan's economy of energy efficiency and RPS policies was projected using by the REMI model and is best understood by looking at following economic measures:

- **Michigan Gross Regional Product (GRP)** – This is a quantity which represents the value added of all goods and services generated with in Michigan. REMI's GRP will be is actually Gross State Product (GSP) and will called this throughout the report.
- **Michigan Employment** – Employment in all sectors of Michigan's economy.
- **Michigan Disposable Personal Income** – Total personal income in real dollars from all of Michigan's workers. This quantity excludes taxes and other mandatory societal contributions.

These factors will change from year to year depending upon Michigan's economic activity. REMI looks at economic impacts on a year to year basis, with limited synergy between each year's economy projections. Therefore, parameters such as size of workforce, personal income, business revenues, etc. can vary significantly from year to year. As such, it is important to first levelize the results throughout the period of the REMI study, and second, to understand the economic trends. The purpose of this Study is to ascertain the economic impacts of energy efficiency and RPS policy on Michigan's economy. As was done throughout this Study, much of the evaluation of Michigan's economic impacts will focus on the differences between each of the policy Cases and the Base Case. As you will see, the REMI projections show very small impacts on Michigan's economy from the energy efficiency or RPS policies. In all of the Cases studied, the largest change in GSP, employment or Disposable Personal Income from the Base Case was less then 0.04%. Other factors in Michigan's economy will have a much larger impact than any of the utility cost impacts resulting from energy efficiency or RPS policies discussed in this report.

Energy efficiency programs or RPS policies cause an impact on Michigan's economy by:

- Changing construction timing of new power plants,
- Changing employment levels in construction and the utility sector,
- Changing electric costs to Michigan businesses and residents.

The construction of a new power plant adds an economic boost from construction jobs, Michigan production of equipment used in the project and services provided to the project. A new base load coal generation facility is projected to cost between $800 million and $1.6 billion and will be constructed over a six year period. Under Michigan's current utility regulation, the cost of this project is not incorporated into electric rates until the plant is in operation. The cost recovery cycle for any type of generation in utility prices, fossil or renewables, is typically in excess of 20 years.

The second economic impact is on employment within the utility sector. In the REMI model, all employment gains from generation plant operations and energy efficiency programs were assigned to the utility sector. Employment caused by construction of new generation plants was distributed through various portions of Michigan's economy, such as construction, metal fabrication and utilities.

The third economic impact, changes in electric costs, affects business spending and consumer spending. Electric price changes are projected by ENERGY 2020 and incorporated into the REMI modeling. Electric costs are affected by new capacity additions, fuel costs, operation & maintenance (O&M) costs, etc. For the energy efficiency Cases EE1 and EE2, electric prices are also affected by energy efficiency program costs and reductions in electric consumption. The impact on electric costs of renewable energy Cases RPS1 & RPS2 are similar to the Base Case because the additional generation sources are incorporated into the utilities' cost structure with no change in electric consumption.

The implementation of energy efficiency programs affect Michigan's economy by reducing utility expenditures by Michigan businesses and residents and by changing the timing on or eliminating construction of new generation facilities. The implementation of energy efficiency programs and RPS policies cause changes to construction of new fossil generation facilities and changes in utility costs. The changes in utility costs caused by energy efficiency programs and RPS policies also eliminate fuel and O&M costs.

Michigan's economy is impacted by the construction cycles of new generation facilities and the construction cycle is not uniform in this study. Annual variations in GSP, employment and disposable personal income make it difficult to compare the results from REMI on an annual basis. To better explain the impacts on Michigan's economy projected by REMI, the Study focused on quantities and timing to smooth out the annual differences for GSP, employment and disposable personal income over the period from 2006 through 2020. For GSP and disposable personal income, the net present value ("NPV") over the period will be used to summarize the results for each of the cases studied. The NPV for GSP and disposable personal income was calculated using a discount rate of 2.5% because all of the figures were calculated in 2006 dollars. The REMI results reported in this Study for the projection of Michigan employment include figures showing the sum of the changes in employment from the Base Case over the period from 2006 through 2020.

## *6.1 Gross State Product*

The impact upon Michigan's GSP is affected more by the building cycles associated with addition of new capacity than it is affected by electric prices. The differences in Michigan's annual GSP were very small, as can be seen in Chart 6.2. In fact, the largest percentage change in GSP was less than 0.04%.

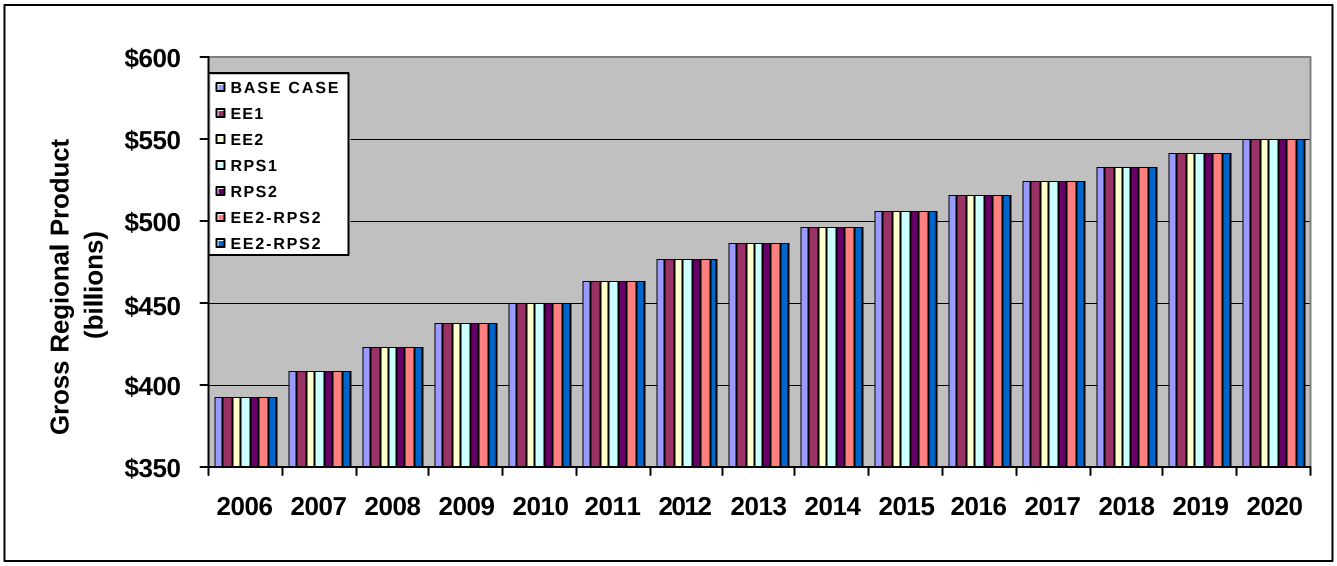



**Chart 6.1 - Michigan GSP**

The percentage changes in Michigan's GSP from the Base Case, are shown in Chart 6.2. The variations in differences in GSP from the Base Case shown in this chart are primarily caused by the construction cycle of new generation facilities.

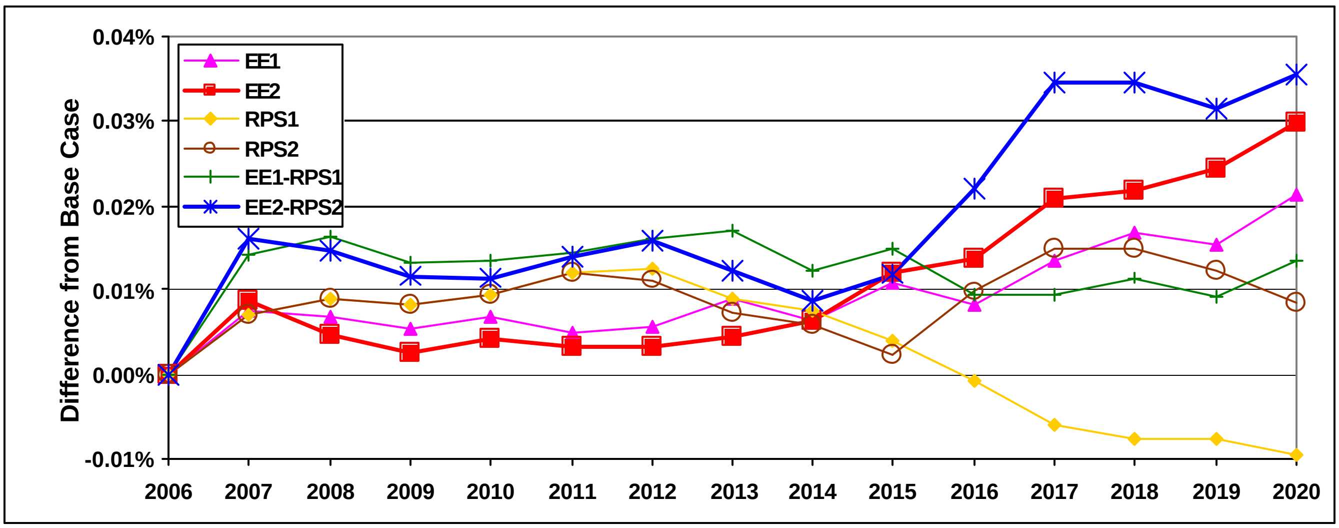



**Chart 6.2 - Michigan GSP % Difference from Base Case**

Table 6.1 presents REMI's projection of GSP for each of the Cases and the difference in GSP from the Base Case for representative years of the Study. This Table also provides the NPV of the GSP for each case over the period of 2006-2020 and the difference in the NPVs of the GSP from the Base Case.

**Table 6.1 - Michigan GSP for Representative Years**

| | 2007-2020 NPV | | | 2015 | | | 2020 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Billions | Differ from Base Case ($Mil) | Differ from Base Case | Billions | Differ from Base Case ($Mil) | Differ from Base Case | Billions | Differ from Base Case ($Mil) | Differ from Base Case |
| Base Case | $5,642 | | | $506.8 | | | $550.3 | | |
| EE1 - Low Penetration Energy Efficiency Case | $5,642 | $553 | 0.010% | $506.9 | $55 | 0.011% | $550.4 | $117 | 0.021% |
| RPS1 - Low Renewable Case | $5,642 | $194 | 0.003% | $506.9 | $20 | 0.004% | $550.3 | ($52) | (0.009%) |
| EE1-RPS1 - Combined Low RPS & Penetration Energy Efficiency Case | $5,642 | $750 | 0.013% | $506.9 | $77 | 0.015% | $550.4 | $75 | 0.014% |
| EE2 - Moderate Penetration Energy Efficiency Case | $5,642 | $637 | 0.011% | $506.9 | $62 | 0.012% | $550.5 | $164 | 0.030% |
| RPS2 - Moderate Renewable Case | $5,642 | $533 | 0.009% | $506.9 | $12 | 0.002% | $550.4 | $47 | 0.008% |
| EE2-RPS2 - Combined Moderate RPS & Moderate Penetration Energy Efficiency Case | $5,643 | $1,102 | 0.020% | $506.9 | $61 | 0.012% | $550.5 | $195 | 0.035% |
| *RPS Cases with all Wind Components Produced in Michigan* | | | | | | | | | |
| RPS1-Wind | $5,642 | $455 | 0.008% | $506.9 | $50 | 0.010% | $550.3 | ($44) | (0.008%) |
| RPS2-wind | $5,643 | $1,627 | 0.029% | $506.9 | $42 | 0.008% | $550.6 | $327 | 0.059% |

### 6.1.1 Energy Efficiency Cases

REMI projections of GSP indicate Michigan's economy will continuously improve over the Base Case with the implementation of energy efficiency programs similar to cases EE1 and EE2. The GSP for Cases EE1 and EE2 is higher than the Base Case GSP for all years in the Study, as can be seen in Chart 6.2. The GSP for Case EE1 is $117 million (0.021%) higher then the Base Case in 2020[26]. For Case EE2, the GSP is $195 million (0.035%) higher then the Base Case in 2020[27]. If you were to draw a trend line on Chart 5.2 between 2006 and 2020 for either Case EE1 or Case EE2, this trend line would show continued improvement in Michigan's GSP for these two cases over the Base Case. The cumulative benefit of the energy efficiency programs in Case EE1 over the Base Case for the period of this Study is shown with a NPV of the GSP difference of $553 million (0.01%). For Case EE2, the NPV of the GSP difference over the Base Case is even higher at $637 million (0.011%). From these results it is clear that implementation of energy efficiency programs will improve Michigan's GSP.

### 6.1.2 RPS Cases

The impact of RPS on Michigan's GSP is less obvious because of annual variations in the GSP. The impact of the construction cycles for new capacity results in some large variations in each case's GSP, as compared to the Base Case. The GSP for the low RPS case (RPS1) is higher then the Base Case during the construction cycle of renewable generation projects, but then becomes lower than the Base Case after the RPS target is reached. The higher GSP for Case EE1 during the construction cycle more then offsets the lower GSP after 2015, as demonstrated by the NPV of the GSP difference from the Base Case of $194 million (0.003%) After 2015, Case EE1's GSP averages about 0.007% lower

[26] See Table J in Appendix B
[27] ibid

then the Base Case GSP[28]. The trend in lower GSP in the Base Case for Case EE1 appears to stabilize in the range of about the 0.006% after 2018. The lower GSP is being caused by a reduction in utility jobs and higher electric costs reducing business and consumer spending on goods and services. Although there is a trend toward a reduction in GSP in the long term, the reduction in GSP is very minor. It is the conclusion of the modeling team that this level of GSP difference from the Base Case is within modeling error. Thus the results for impact on Michigan's GSP for a RPS target level of 7% shows there will be minimal impact on Michigan's economy under current environmental and regulatory conditions.

As can be seen in Chart 6.2, the GSP for the moderate RPS case (RPS2) is higher than the Base Case through out the results period. The growth in GSP for Case EE2 over the Base Case is due to construction spending for both renewable and fossil generation added during this period. The impact on GSP of increased electric costs is offset by the increased construction spending. REMI projects Case RPS2's GSP to be about $47 million (0.008%) higher then the Base Case in 2020.[29] But as with Case RPS1, it is difficult to determine the trend in GSP for Case RPS2 from Chart 6.2. The NPV of the difference in Case RPS2's GSP from the Base Case's GSP is higher by $533 million (0.009%). This is only about 16% lower than the NPV of the GSP difference for Case EE2. If Case RPS2 follows a similar course to Case RPS1, the difference in GSP will move toward a slightly lower GSP than the Base Case, once the construction period for renewables ends. But as in Case EE1, this difference in Michigan's GSP from the Base Case is likely to be negligible.

### 6.1.3 Combined Energy Efficiency & RPS Cases

REMI projections of Michigan's GSP for the cases which combined energy efficiency programs with RPS policy indicate that this combination will improve the State's GSP. Chart 6.2 shows an increase in GSP over the Base Case in all years for the Study for both Case EE1-RPS1 and EE2-RPS2. The GSP results are approximately equal to the sum of the results of the stand alone energy efficiency cases and RPS cases. The NPV of the differences in GSP from the Base Case shows an increase of $750 million (0.013%) for Case EE1-RPS1, over the Base case in 2020[30]. The NPV of the differences in GSP from the Base Case in 2020, for Case EE2-RPS2 is even greater (over $1.1 billion or 0.02%). This clearly shows that the combination of a moderate penetration energy efficiency program with a moderate RPS target will cause Michigan's GSP to grow the most of all cases (excluding the Cases RPS1-Wind and RPS2-Wind discussed below).

[28] ibid
[29] See Table J in Appendix B
[30] Ibid.

#### 6.1.4 Michigan RPS Manufacturing Cases

The renewable cases modeled by REMI to have 100% of the renewable components manufactured in Michigan, showed significant improvement in GSP over all cases. The NPV of the difference in GSP from the Base Case grows to $455 million (0.008%) for Case RPS1-Wind and to $1.6 billion (0.029%) for Case RPS2-Wind (see Table 6.1). The importance of these cases is that they show the economic benefit of attracting a new wind manufacturing industry to Michigan.[31]

## 6.2 Employment

The employment picture is cyclical, similar to the State's GSP. There are two key contributors to how REMI predicted employment levels: the construction cycle and disposable personal income. Employment varies from the Base Case between 0.037% and minus 0.008% of the Base Case Employment levels. The project employment level for each case is shown in Chart 6.3. As with Michigan's GSP, the impacts on employment levels can be better observed by looking at the difference in employment for

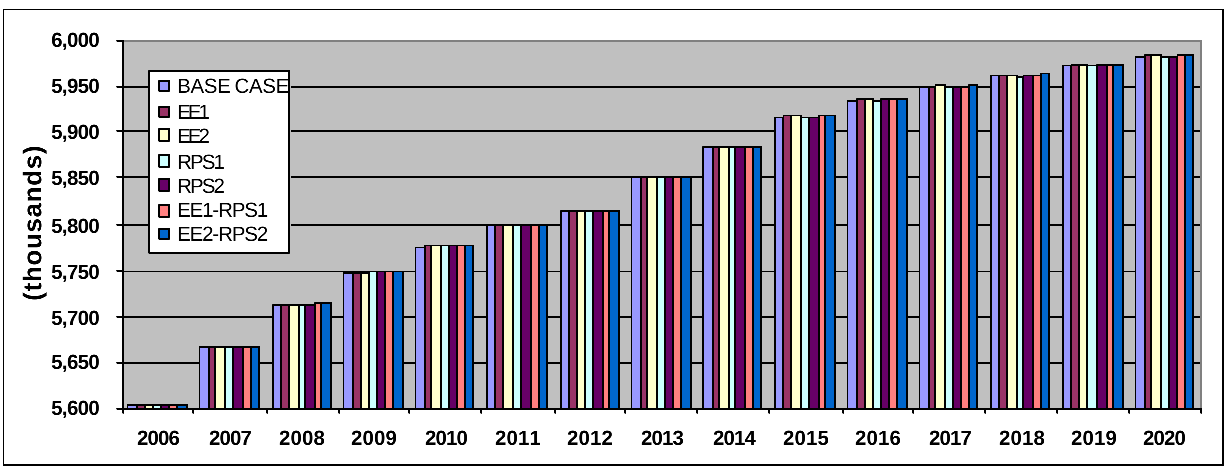



**Chart 6.3 - Michigan Employment Levels**

each case relative to the Base Case, as shown in Chart 6.4. Energy efficiency Cases EE1 and EE2 have a positive impact on employment levels throughout the period. In 2020, Case EE1 projects employment to increase by nearly 1,400 jobs over the Base Case. REMI projects the total increase in employment levels for Case EE1 will be

[31] These findings correlate well to a recent report issued by the Renewable Energy Policy Project (REPP) in November 2006, entitled "Component Manufacturing: Michigan's Future in the Renewable Energy Industry". The report provides a detailed county and individual site level account of manufacturing potential for wind, solar, geothermal, and biomass energy systems in Michigan, and concludes that here are 2,050 firms in Michigan with the potential to manufacture renewable energy components. In addition, the report determined that, to satisfy a national renewable energy requirement of 124,900 MW, these firms would require incremental investment in excess of $5 Billion, and add 34,777 new full-time equivalent jobs.

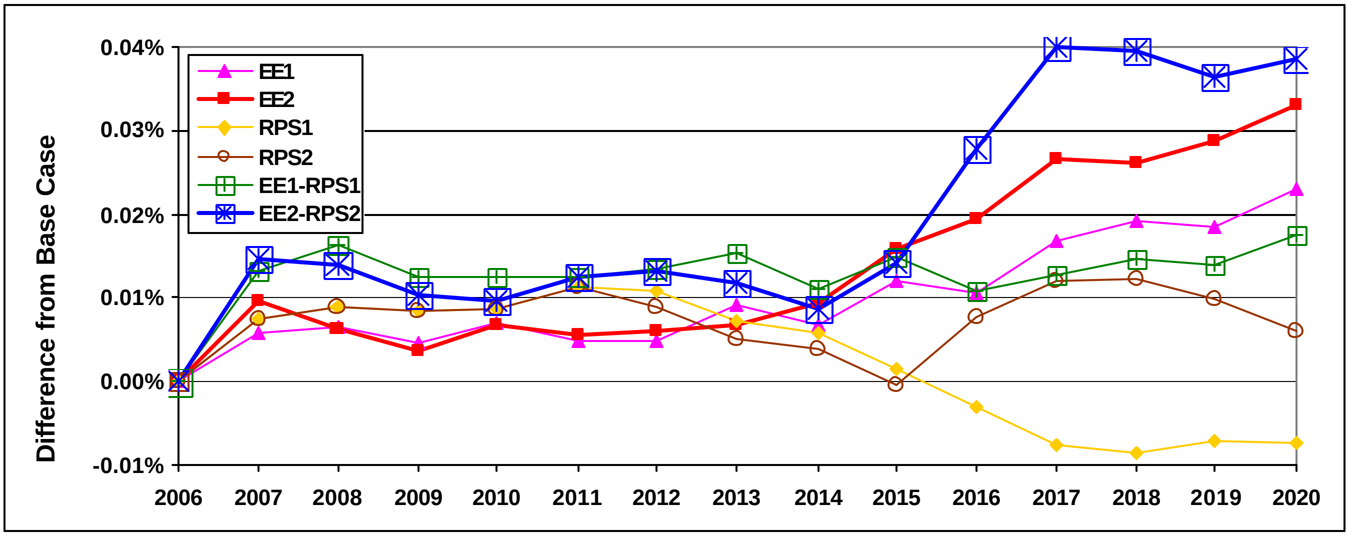



**Chart 6.4 - Michigan Employment % Difference from Base Case**

8,783 jobs higher than the Base Case throughout the period, as seen in Table 6.2.[32] Projections for Case EE2 indicate an increase in employment over the Base Case of nearly 2,000 jobs by 2020. REMI projects the total increase in jobs created over the period of 2006-2020 for case EE2 will be 12,057 jobs higher than the Base Case.[33]

Projected employment levels for the RPS cases indicate an uneven but ultimately positive net result. During certain years, Case RPS1 is projected to have higher employment than the Base Case and in other years lower, but with the cumulative result higher. In 2020, REMI is predicting Case RPS1 to result in a reduction of 436 jobs (0.007%) as compared to the Base Case. The total increase in employment level for Case RPS1 over the period 2006-2020 is projected to be 8,783 jobs higher than the Base Case.[34] For Case RPS2, REMI projects employment gains of 358 jobs (0.006%) in 2020, versus the Base Case. For much of the period of the study, Case RPS2 is projected to have higher employment levels than the Base Case. The total increase in employment levels for Case RPS2 over

[32] These figures represent a summation of the number of jobs created or eliminated within each year of the study.
[33] Ibid.
[34] Ibid

| | 2007-2020 Total Change | | | 2015 | | | 2020 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Difference from Base Case | | Differ from Base Case | Thous | Differ from Base Case (annually) | Differ from Base Case | Thous | Differ from Base Case (annually) | Differ from Base Case |
| **Base Case** | 5,874 | | | 5,917 | | | 5,982 | | |
| **EE1** - Low Penetration Energy Efficiency Case | | 8,783 | 0.011% | 5,918 | 707 | 0.012% | 5,984 | 1,381 | 0.023% |
| **RPS1** - Low Renewable Case | | 2,020 | 0.002% | 5,917 | 83 | 0.001% | 5,982 | (436) | (0.007%) |
| **EE1-RPS1** - Combined Low RPS & Penetration Energy Efficiency Case | | 11,204 | 0.014% | 5,918 | 886 | 0.015% | 5,983 | 1,054 | 0.018% |
| **EE2** - Moderate Penetration Energy Efficiency Case | | 12,057 | 0.015% | 5,918 | 935 | 0.016% | 5,984 | 1,979 | 0.033% |
| **RPS2** - Moderate Renewable Case | | 6,381 | 0.008% | 5,917 | (39) | (0.001%) | 5,983 | 358 | 0.006% |
| **EE2-RPS2** - Combined Moderate RPS & Moderate Penetration Energy Efficiency Case | | 17,191 | 0.021% | 5,918 | 843 | 0.014% | 5,984 | 2,313 | 0.039% |
| ***RPS Cases with all Wind Components Produced in Michigan*** | | | | | | | | | |
| **RPS1-Wind** | | 5,029 | 0.006% | 5,917 | 367 | 0.006% | 5,982 | (372) | (0.006%) |
| **RPS2-wind** | | 19,005 | 0.023% | 5,917 | 245 | 0.004% | 5,985 | 2,672 | 0.045% |

**Table 6.2 - Michigan Employment Impacts Summary**

the period of 2006-2020 is projected by REMI to be 12,057 jobs higher than the Base Case.[35] The impact on jobs is caused by two factors in the REMI model; the building cycles caused by adding new capacity and electric prices. This impact is more pronounced in the RPS cases because of the higher projected electric rates. Increased electric costs reduce the amount consumers have to spend on other goods and services. In the REMI model, this results in losses in the transportation and services sectors. Case RPS1 shows this impact starting in 2016. Employment levels up through 2015 for Case RPS1 are increased by the jobs created in building out new renewable capacity. The effects on Michigan's employment levels due to increases in electric prices from the costs of renewable additions starts to become dominant in 2016. The lower employment levels peak in 2018, after which they again begin to climb. After 2018, employment levels start to move back toward that of the Base Case. The movement of employment levels back toward those of the Base Case occurs when electric prices move closer to the prices in the Base Case due to the benefits of renewables (lower fuel and O&M costs).

As with REMI's prediction of GSP results, the projected impact on Michigan's employment levels for the combined energy efficiency/RPS cases is essentially the same as the sum of the employment impacts of the cases on their own.

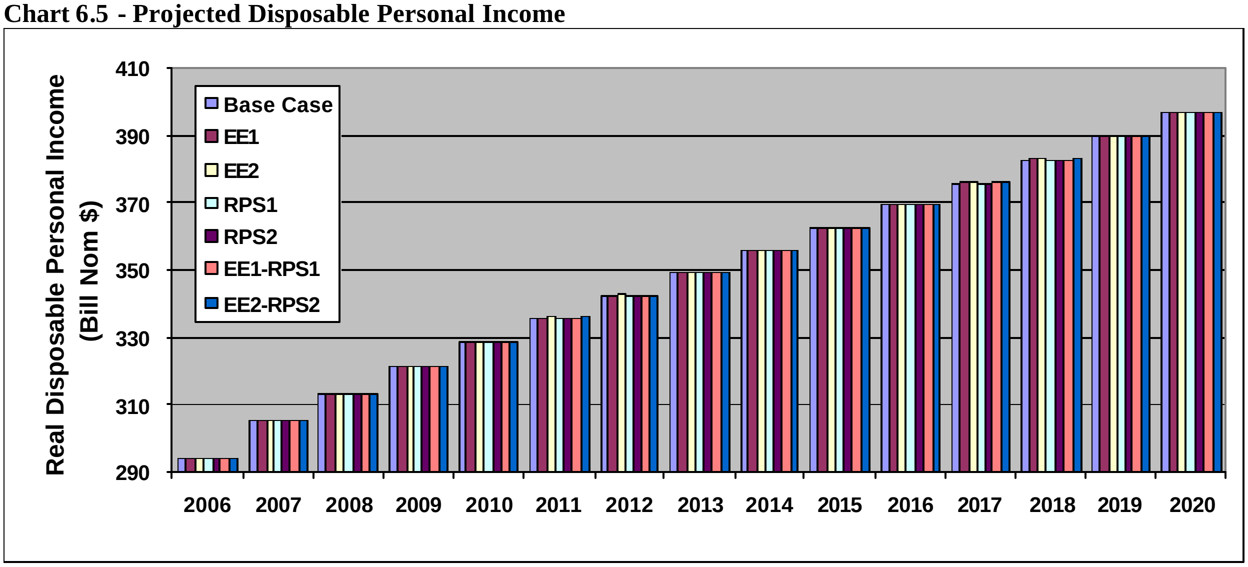
As expected, increasing the Michigan content of components manufactured for wind generation is projected to cause an increase in Michigan employment. The average annual increases almost triple for Cases RPS1-Wind and RPS2-Wind when compared to the standard RPS cases. Employment is projected to average 359 jobs higher for Case RPS1-Wind and 1,358 jobs higher for Case RPS2-Wind as compared to the Base Case.[36]

[35] See footnote 33.
[36] See footnote 33.

## *6.3 Disposable Personal Income*

Disposable personal income ("DPI") is an important economic driver for Michigan's economy. This study found the variation in DPI to be within ± 0.05% of the Base Case figures. The projected DPI for each case is shown in Chart 6.5. DPI affects the ability of Michigan residents to purchase goods and services. DPI is affected by the number of jobs available and the value of those jobs. The graph in Chart 6.5 shows there is very

**Chart 6.5 - Projected Disposable Personal Income**




little relative impact on disposable income by the various cases included in the Study (not including special Michigan manufacturing Cases RPS1-Wind and RPS2-Wind). The graph in Chart 6.6 shows the difference in disposable income between each of the six primary cases and the Base Case. The chart shows that for the energy efficiency cases,

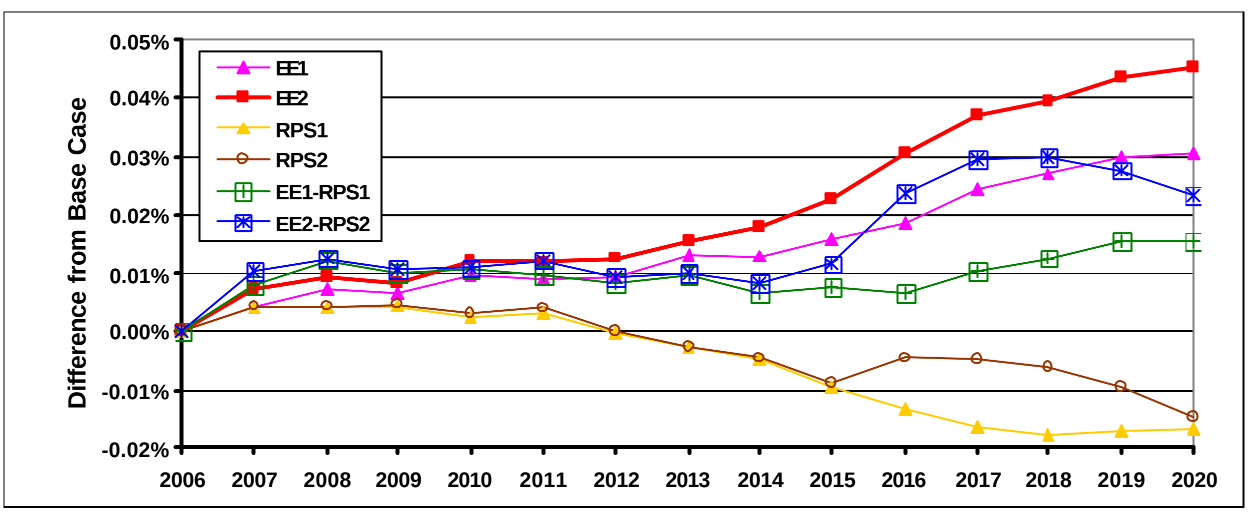



**Chart 6.6 - Disposable Income Difference from Base Case**

Cases EE1 and EE2, DPI is improved over that of the Base Case. By 2020, DPI for Case EE1 is $121 million higher than the Base Case. This equates to 0.03% improvement over the Base Case. Over the period of the study, REMI projects Case EE1 to improve DPI a total of $628 million over the Base Case on a NPV basis. REMI projects the 2020 DPI for Case EE2 to be $180 million higher than the Base Case. On a NPV basis, Case EE2 is projected by REMI to provide an increase in DPI of over $904 million over the period between 2006 and 2020.

The RPS cases are projected by REMI to have mixed results on the DPI, when compared to the Base Case. Cases RPS1 and RPS2, without any energy efficiency programs (EE1 or EE2) to supplement them, are both projected to have slightly lower DPI than the Base case after 2012. Utilizing either EE1 or EE2 in conjunction with RPS1 or RPS2 reverses this negative result however, achieving an overall rise in DPI. Case EE1-RPS1 is projected by REMI to improve DPI by $62 million over the Base Case by 2020. Case EE2-RPS2 is projected by REMI to improve the 2020 DPI by $92 million over the Base Case.

As with the other two economic parameters, Michigan's DPI under a RPS policy will improve with an increase in Michigan manufacturing of wind energy components. REMI projects the 2020 DPI for Case RPS1-Wind will improve by about $5 million over Case RPS1. The 2020 DPI for case RPS2-Wind will improve by about $88 million over the Base Case. These improvements are due to increased manufacturing jobs caused by the production of wind components.

| | 2007-2020 NPV | | | 2015 | | | 2020 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Billions | Differ from Base Case ($Mil) | Differ from Base Case | Billions | Differ from Base Case ($Mil) | Differ from Base Case | Billions | Differ from Base Case ($Mil) | Differ from Base Case |
| Base Case | $4,085 | | | $362.6 | | | $396.9 | | |
| EE1 - Low Penetration Energy Efficiency Case | $4,085 | $628 | 0.015% | $362.7 | $57 | 0.016% | $397.1 | $121 | 0.030% |
| RPS1 - Low Renewable Case | $4,084 | ($229) | (0.006%) | $362.6 | ($35) | (0.010%) | $396.9 | ($67) | (0.017%) |
| EE1-RPS1 - Combined Low RPS & Penetration Energy Efficiency Case | $4,085 | $415 | 0.010% | $362.6 | $27 | 0.008% | $397.0 | $62 | 0.016% |
| EE2 - Moderate Penetration Energy Efficiency Case | $4,085 | $904 | 0.022% | $362.7 | $82 | 0.023% | $397.1 | $180 | 0.045% |
| RPS2 - Moderate Renewable Case | $4,084 | ($100) | (0.002%) | $362.6 | ($32) | (0.009%) | $396.9 | ($58) | (0.015%) |
| EE2-RPS2 - Combined Moderate RPS & Moderate Penetration Energy Efficiency Case | $4,085 | $664 | 0.016% | $362.6 | $42 | 0.012% | $397.0 | $92 | 0.023% |
| *RPS Cases with all Wind Components Produced in Michigan* | | | | | | | | | |
| RPS1-Wind | $4,084 | ($113) | -0.003% | $362.6 | ($21) | -0.006% | $396.9 | ($62) | (0.016%) |
| RPS2-wind | $4,085 | $246 | 0.006% | $362.6 | ($26) | -0.007% | $397.0 | $30 | 0.008% |

**Table 6.3 - Michigan Disposable Personal Income Impacts Summary**

## *6.4 Summary of Economic Impacts*

### 6.4.1 Energy Efficiency Policy Impacts on Michigan's Economy

The Study reveals that Michigan's first priority should be the implementation of energy efficiency programs. The two cases tested, EE1 and EE2 show a positive improvement over the Base Case for all aspects of Michigan's economy. Energy efficiency programs recommended by the MPSC Staff show improvement over the Base Case in employment by almost 2,000 jobs, improvement in disposable personal income of over $180 million and GSP improvement of $164 million by 2020. Looking at REMI's projections of GSP, employment and DPI for the various sectors of Michigan's economy, the only sector with significant negative impact is the utility sector. The reduction in electric consumption will delay the construction of new generation, reduce utility employment and reduce utility costs. All other sectors show neutral or positive gains in GSP. It is for these reasons that Michigan should quickly and aggressively move forward on policies that promote and cause the implementation energy efficient programs.

### 6.4.2 RPS Policy Impacts on Michigan's Economy

The differences from the Base Case for Cases RPS1 and RPS2 in Michigan's GSP, employment and DPI are minor under current market conditions. However, there is growing evidence that the assumptions for construction costs of fossil generation used in both this Study and the $21^{st}$ CEP are low. Should fossil fuel price escalations considered in this analysis prove to be low, Michigan's economy will benefit both in the short term and the long term from the construction of renewable generation instead of fossil generation. The potential cost of carbon tax will also cause the economic projections for the Base Case to worsen.

Since the modeling in Cases RPS1 and RPS2 utilize conservative assumptions, the positive projected impact on Michigan's economy is lower than is likely to actually occur. As discussed earlier, the capacity factor and contribution to utility reserve margins used in both this Study and the $21^{st}$ CEP are low based upon current data. This causes higher utility costs in the RPS cases which negatively impact the projected GSP and other aspects of Michigan's economy. The potential revenue from carbon trading was not included in the modeling. This would offset higher utility costs further.

### 6.4.3 Combined Energy Efficiency and RPS Policy Impacts on Michigan's Economy

It is clear from the REMI modeling results that combining the implementation of both energy efficiency and RPS policies will provide the most benefit to Michigan's economy. The REMI modeling also shows that combining programs does not cause any unexpected consequences.

### 6.4.4 Economic Impacts of Attraction of Renewable Energy Component Manufacturing

The inclusion within the Study of cases incorporating the manufacturing of renewable energy components in Michigan illustrates the significant positive impact on Michigan's economy of using Michigan's production capability to manufacture the wind turbine components necessary to satisfy Michigan's incremental demand for wind energy systems. Cases RPS1Wind and RPS2Wind assume that all components required for wind energy systems required in Cases RPS1 and RPS2 are satisfied by manufacturers located in Michigan. These cases use the results from ENERGY 2020 for Cases RPS1 and RPS2 and adjust the allocation of renewable components to be produced from Michigan resources only. Strictly as an illustration, the results demonstrate, as expected, that the attraction of additional manufacturing of wind components to Michigan would improve the State's economy. In reality, not all components could be expected to be manufactured in Michigan. However, the specific wind energy component products manufactured in Michigan would also be indicative of Michigan-made products eminently marketable to out-of-state and international wind system operators, as well. The effect of exporting wind components from Michigan manufacturing was ignored in this study.

- The modeling of RPS1-Wind with Michigan manufacturing improves the NPV of Michigan's GSP for the period between 2007 -2020, over the Base Case by about $455 million and $260 million over Case RPS1.

- The modeling of RPS2-Wind with Michigan manufacturing improves the NPV of Michigan's GSP for the period between 2007-2020, over the Base Case by over $1.6 billon and $1.1 million over Case RPS2.

- Both RPS1-Wind and RPS2-Wind with Michigan manufacturing included result in a net positive in employment over the Base Case as well.

The major benefit of Michigan aggressively seeking to attract manufacturing of renewable energy components can be seen in Tables 6.1, 6.2 and 6.3. Employment levels are expected to increase when new industry is located in Michigan and the modeling results reported in Table 6.2 show this effect. Increases in employment levels for Cases RPS1-Wind and RPS2-Wind are nearly three times higher than for Cases RPS1 and RPS2. The NPV of disposable personal income for the period of 2006 to 2020 increases by $346 million for Case RPS2-Wind over that of Case RPS2. This change is due to the creation of new jobs in the renewable energy manufacturing sector.[37]

Certainly, Michigan's economy has already benefited from job additions in renewable energy component manufacturing. For example, United Solar Ovonic, a subsidiary of Energy Conversion Devices, with headquarters in Auburn Hills Michigan, announced three manufacturing plant additions in Michigan in the last

[37] See footnote 32.

24 months, with an overall intention of expanding capacity by over 300 MW by 2010. Over 1000 incremental jobs are expected through these capacity additions. In addition, in late 2005, Hemlock Semiconductor, a leader in the production of polycrystalline silicon for solar cells, began construction of a $400-$500 Million expansion, resulting in hundreds of construction and full time manufacturing jobs in Hemlock, Michigan.[38]

[38] The state of Pennsylvania has been especially aggressive in targeting renewable energy manufacturers enabled, in part, through its adoption of a 20% Renewable Portfolio Standard by 2010. In October, 2004, Spanish wind energy company Gamesa Energy, announced that they will create as many as 1000 direct jobs in the state, consisting of operations at a new North American Headquarters, wind component manufacturing facilities, and the design and construction of wind energy projects. In the February 1, 2007 unveiling of his $10 Billion "Energy Independence Strategy", Governor Edward Rendell stated that Pennsylvania's current energy investment programs have created over 2,500 jobs in the state.

# 7 Conclusions, Limitations and Suggestions for Further Study

The results of this Study are significant and important from energy policy and economic development policy perspectives.

## 7.1 Conclusions

The following is a brief a summary of the conclusions from this Study:

1. Implementation of energy efficiency programs at the levels included in the 21st CEP will result in significant economic benefit to Michigan over the Base Case.

2. Economic impacts (GSP and employment) from a RPS are likely to be positive over the life cycle of renewable power generation plants (versus fossil generation plants).

3. During specified periods within the Study's timeline, minimal negative impact to Disposable Personal Income (DPI) is projected to occur in certain of the RPS-only cases. Due to the long term reduction in fuel and operating costs of renewable assets, improved economic results for all energy efficiency and RPS cases are likely, if the study timelines were extended to encompass the entire useful life of the power generation assets.

4. A combined Energy Efficiency and RPS will defer the need for new coal generation and its associated emissions and environmental impact.

5. Emission reductions illustrated in all the cases studied are significant and could have significant value to Michigan's residents, above that reflected in the calculations of GSP, employment and DPI.

6. If a state or national RPS were to be put in place, Michigan could gain considerably relative to other states since it is a superior location for wind resources, manufacturing job potential and investment[39]

## 7.2 Limitations and Caveats

The models used in this Study analyzed Michigan's economy on a macro basis and have limited ability to analyze specific industry impacts. Therefore, the positive economic impact of energy efficiency and RPS programs found in this Study are based upon a macro view of the State's economy. Certain businesses could experience negative impacts due to electric price changes or an inability to take advantage of energy efficiency programs.

[39] See footnote 32.

Additional limitations or uncertainties include the following:

- **Wind Capacity Factor and Peak Hour Contribution**: The 21st CEP assumed wind power's capacity factor was only 28% and its contribution to capacity was only 12%. These assumptions were also included in the ENERGY 2020 modeling. These figures may be low based upon data available from various sources, resulting in a conservative set of results for the RPS cases.[40]

- **Regulatory (Market) Structure**: The analysis does not distinguish between generation or retail customer ownership under Michigan's current "hybrid" market structure, and assumes that the policies contemplated would apply to electricity sales to all customers.

- **Future Carbon Regulations**: Although the Study addresses the benefits of selling carbon credits on a cursory basis, no attempt was made to incorporate tighter carbon emissions regulations in the calculations of GSP, employment, or DPI.[41]

- **Coal Supply Problems:** Several articles and studies have pointed out the pending potential constraints in the infrastructure needed to move coal to market. Current rail capacity is becoming a limiting factor and production capacity is limited.[42] One study suggested that for the U. S. to fuel the projected new round of coal power plants, as much as 20% of the coal may have to be imported. All this could lead to unexpected cost increases in coal price.

- **Capital Cost Uncertainties:** The study generally relies upon capital cost data from Michigan's 21st Century Energy Plan. Recent projections by Duke Energy and others have indicated sharp increases in coal production facility costs to as high as $1,800 per KW (nearly 50% increase). Given expected demand for renewable energy components, especially for wind turbines, renewable costs may experience additional cost increases as well.

- **Transmission Infrastructure:** Variations in incremental transmission investment across each of the cases were ignored due to uncertainties in the location of actual power plants installed. Actual variations in transmission costs may have an effect on the relative economic impacts of the cases.

[40] For example, the PJM Independent System Operator allows 20% of wind power capacity to be counted toward the capacity a utility has available to meet peak conditions. In addition, many of the Michigan sites being considered for wind power are forecasted to have a capacity factor of about 32%, over 14% higher than the figure used in this Study.
[41] For a detailed analysis of the net economic impacts to Michigan's economy associated with the implementation of various greenhouse gas reduction strategies, see "Michigan at a Climate Crossroads", University of Michigan Center for Sustainable Systems, April 2007 (Report No. CSS07-02).
[42] Gary L Hunt, "A Wakeup Call for Coal", *Public Utilities Fortnightly*, December 2006, pg 14.

## *7.3 Suggestions for Further Study*

The areas of further study include refinements on the models used in this Study and focused analysis of specific issues. Below is a list of potential further investigation which could lead to a better understanding of the ramifications of energy efficiency and RPS policies:

A. **Industry Impact Analysis**: Analyze the potential opportunities for energy efficiency improvements within specific Michigan industries and study the impacts of electric price increases on those industries' competitiveness.
B. **Fuel Price Sensitivity:** Perform an analysis of how likely changes in fuel price will affect the results of this analysis.
C. **Carbon Tax Impacts:** Conduct a sensitivity analysis on the impacts of carbon taxes on Michigan's economy for each of the policies included in this study.
D. **Wind Power Capacity Factor:** Upgrade the capacity credit for wind power. Conduct sensitivity analyses over the range of wind power capacity factors to determine how it affects electric prices and Michigan's economy.
E. **Longer Term Impacts:** The modeling results encompass the period through 2020 only. A longer term analysis (e.g. 25-30) years would likely show an improvement to all of the energy efficiency and renewable cases due to the expected long term benefits of lower fuel and operating costs, especially for Wind. In addition, under the Low RPS Scenario (RPS1), the 7% renewable energy level is held constant beginning in 2016, and is to be likely conservative based on actual RPS experience in other states.

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NEXTENERGY

ECONOMIC SECURITY THROUGH ENERGY DIVERSITY

# A Study of Economic Impacts from the Implementation of a Renewable Portfolio Standard and an Energy Efficiency Program in Michigan

**Produced by: NextEnergy**
**Prepared for: Michigan Department of Environmental Quality (MDEQ)**

# APPENDICES

April, 2007

# INDEX TO APPENDICIES



# LIST OF TABLES IN APPENDIX

# APPENDIX A – Generation Data Tables

**Table A - Michigan Electric Sales (GWh)**

| | Base Case | EE1 | EE2 | RPS1 | RPS2 | RPS1-EE1 | RPS2-EE2 |
|---|---|---|---|---|---|---|---|
| 2006 | 111,096 | 111,096 | 111,096 | 111,097 | 111,097 | 111,097 | 111,097 |
| 2007 | 112,323 | 111,894 | 111,585 | 112,327 | 112,327 | 111,899 | 111,588 |
| 2008 | 114,036 | 113,183 | 112,554 | 114,036 | 114,036 | 113,183 | 112,552 |
| 2009 | 115,291 | 114,005 | 113,057 | 115,286 | 115,286 | 113,997 | 113,048 |
| 2010 | 116,404 | 114,689 | 113,424 | 116,385 | 116,385 | 114,668 | 113,398 |
| 2011 | 118,506 | 116,358 | 114,768 | 118,473 | 118,473 | 116,321 | 114,729 |
| 2012 | 120,588 | 118,004 | 116,087 | 120,527 | 120,526 | 117,941 | 116,016 |
| 2013 | 122,554 | 119,538 | 117,294 | 122,460 | 122,459 | 119,440 | 117,184 |
| 2014 | 124,564 | 121,113 | 118,542 | 124,434 | 124,433 | 120,976 | 118,392 |
| 2015 | 126,620 | 122,730 | 119,836 | 126,447 | 126,446 | 122,554 | 119,650 |
| 2016 | 126,776 | 122,457 | 119,248 | 126,562 | 126,573 | 122,239 | 119,035 |
| 2017 | 127,089 | 122,347 | 118,820 | 126,835 | 126,841 | 122,091 | 118,563 |
| 2018 | 128,876 | 123,709 | 119,860 | 128,585 | 128,566 | 123,421 | 119,545 |
| 2019 | 130,792 | 125,207 | 121,034 | 130,464 | 130,409 | 124,884 | 120,639 |
| 2020 | 132,723 | 126,707 | 122,209 | 132,362 | 132,252 | 126,350 | 121,718 |
| 2021 | 134,920 | 128,462 | 123,641 | 134,532 | 134,343 | 128,082 | 123,034 |
| 2022 | 136,796 | 129,895 | 124,746 | 136,390 | 136,104 | 129,488 | 124,010 |
| 2023 | 138,695 | 131,351 | 125,868 | 138,287 | 137,896 | 130,927 | 124,998 |
| 2024 | 140,789 | 132,998 | 127,162 | 140,314 | 139,789 | 132,561 | 126,153 |
| 2025 | 142,894 | 134,716 | 128,528 | 142,394 | 141,698 | 134,275 | 127,368 |

**Table B - Michigan Generation Capacity (MW)**

| | Base Case | EE1 | EE2 | RPS1 | RPS2 | RPS1-EE1 | RPS2-EE2 |
|---|---|---|---|---|---|---|---|
| 2006 | 27,475 | 27,475 | 27,475 | 27,475 | 27,475 | 27,475 | 27,475 |
| 2007 | 27,475 | 27,475 | 27,475 | 27,513 | 27,513 | 27,513 | 27,513 |
| 2008 | 27,955 | 27,475 | 27,475 | 28,140 | 28,140 | 27,660 | 27,660 |
| 2009 | 28,115 | 27,475 | 27,475 | 28,213 | 28,213 | 27,733 | 27,733 |
| 2010 | 28,435 | 27,635 | 27,475 | 28,633 | 28,633 | 27,833 | 27,833 |
| 2011 | 28,755 | 27,955 | 27,795 | 28,899 | 28,899 | 28,099 | 27,939 |
| 2012 | 29,415 | 28,615 | 28,455 | 29,737 | 29,737 | 28,777 | 28,687 |
| 2013 | 30,014 | 29,054 | 28,394 | 30,322 | 30,322 | 29,362 | 28,772 |
| 2014 | 30,674 | 29,054 | 28,394 | 30,930 | 30,930 | 29,470 | 28,880 |
| 2015 | 30,925 | 29,305 | 28,805 | 31,291 | 31,291 | 29,581 | 29,151 |
| 2016 | 31,700 | 29,580 | 29,080 | 32,182 | 32,182 | 29,972 | 29,542 |
| 2017 | 32,098 | 29,978 | 29,478 | 32,602 | 32,790 | 30,392 | 30,400 |
| 2018 | 32,436 | 30,816 | 29,816 | 32,964 | 33,632 | 31,254 | 31,242 |
| 2019 | 33,390 | 31,270 | 30,270 | 33,944 | 35,105 | 31,734 | 31,875 |
| 2020 | 33,735 | 31,615 | 30,615 | 34,137 | 35,805 | 32,107 | 32,755 |
| 2021 | 34,333 | 32,033 | 31,213 | 34,760 | 36,968 | 32,390 | 33,918 |
| 2022 | 35,064 | 32,764 | 31,944 | 35,516 | 38,017 | 33,146 | 34,967 |
| 2023 | 35,737 | 33,437 | 32,277 | 36,217 | 39,268 | 33,847 | 35,718 |
| 2024 | 35,737 | 33,437 | 32,277 | 36,217 | 39,268 | 33,847 | 35,718 |
| 2025 | 35,737 | 33,437 | 32,277 | 36,217 | 39,268 | 33,847 | 35,718 |

# APPENDIX A (cont.)

**Table C - Base Case Generation Mix (GWh)**

| | Coal | Nuclear | Gas | Oil | Renewable | Pumped Hydro | TOTAL |
|---|---|---|---|---|---|---|---|
| **2006** | 67,299 | 14,368 | 15,035 | 3,867 | 3,279 | 148 | 103,996 |
| **2007** | 67,299 | 14,368 | 9,142 | 2,361 | 3,279 | 148 | 96,597 |
| **2008** | 67,299 | 14,368 | 7,322 | 1,962 | 3,279 | 148 | 94,378 |
| **2009** | 67,299 | 14,368 | 6,705 | 1,812 | 3,279 | 148 | 93,611 |
| **2010** | 67,299 | 14,368 | 6,549 | 1,807 | 3,279 | 148 | 93,450 |
| **2011** | 67,299 | 14,368 | 9,682 | 2,702 | 3,279 | 148 | 97,478 |
| **2012** | 70,263 | 14,368 | 9,947 | 2,793 | 3,279 | 148 | 100,797 |
| **2013** | 73,226 | 14,368 | 11,750 | 3,266 | 3,279 | 148 | 106,036 |
| **2014** | 76,189 | 14,368 | 11,288 | 3,171 | 3,279 | 148 | 108,444 |
| **2015** | 77,908 | 14,368 | 11,429 | 3,220 | 3,279 | 148 | 110,352 |
| **2016** | 83,772 | 14,368 | 9,122 | 2,603 | 3,279 | 148 | 113,292 |
| **2017** | 85,658 | 14,368 | 9,175 | 2,628 | 3,279 | 148 | 115,255 |
| **2018** | 87,493 | 14,368 | 10,211 | 2,955 | 3,279 | 148 | 118,453 |
| **2019** | 91,921 | 14,368 | 10,229 | 2,960 | 3,279 | 148 | 122,904 |
| **2020** | 93,827 | 14,368 | 11,013 | 3,208 | 3,279 | 148 | 125,843 |
| **2021** | 97,882 | 14,368 | 10,390 | 3,036 | 3,279 | 148 | 129,102 |
| **2022** | 101,502 | 14,368 | 10,042 | 2,929 | 3,279 | 148 | 132,267 |
| **2023** | 104,990 | 14,368 | 9,286 | 2,695 | 3,279 | 148 | 134,766 |
| **2024** | 106,520 | 14,368 | 9,543 | 2,776 | 3,279 | 148 | 136,633 |
| **2025** | 107,052 | 14,368 | 10,341 | 2,912 | 3,279 | 148 | 138,100 |

**Table D - Case EE1 Generation Mix (GWh)**

| | Coal | Nuclear | Gas | Oil | Renewable | Pumped Hydro | TOTAL |
|---|---|---|---|---|---|---|---|
| **2006** | 67,299 | 14,368 | 15,035 | 3,867 | 3,279 | 148 | 103,996 |
| **2007** | 67,299 | 14,368 | 9,076 | 2,344 | 3,279 | 148 | 96,514 |
| **2008** | 67,299 | 14,368 | 7,189 | 1,851 | 3,279 | 148 | 94,134 |
| **2009** | 67,299 | 14,368 | 6,531 | 1,679 | 3,279 | 148 | 93,305 |
| **2010** | 67,299 | 14,368 | 6,340 | 1,650 | 3,279 | 148 | 93,084 |
| **2011** | 67,299 | 14,368 | 7,764 | 2,057 | 3,279 | 148 | 94,915 |
| **2012** | 70,263 | 14,368 | 9,661 | 2,585 | 3,279 | 148 | 100,303 |
| **2013** | 73,226 | 14,368 | 10,362 | 2,730 | 3,279 | 148 | 104,112 |
| **2014** | 73,226 | 14,368 | 10,059 | 2,664 | 3,279 | 148 | 103,743 |
| **2015** | 74,945 | 14,368 | 10,270 | 2,730 | 3,279 | 148 | 105,739 |
| **2016** | 77,846 | 14,368 | 9,240 | 2,475 | 3,279 | 148 | 107,355 |
| **2017** | 79,716 | 14,368 | 9,559 | 2,572 | 3,279 | 148 | 109,642 |
| **2018** | 83,471 | 14,368 | 8,858 | 2,374 | 3,279 | 148 | 112,498 |
| **2019** | 85,664 | 14,368 | 8,778 | 2,352 | 3,279 | 148 | 114,588 |
| **2020** | 87,410 | 14,368 | 9,127 | 2,450 | 3,279 | 148 | 116,782 |
| **2021** | 89,221 | 14,368 | 8,983 | 2,474 | 3,279 | 148 | 118,473 |
| **2022** | 92,676 | 14,368 | 8,769 | 2,413 | 3,279 | 148 | 121,652 |
| **2023** | 95,999 | 14,368 | 9,310 | 2,574 | 3,279 | 148 | 125,679 |
| **2024** | 97,364 | 14,368 | 9,980 | 2,770 | 3,279 | 148 | 127,909 |
| **2025** | 97,747 | 14,368 | 10,582 | 3,012 | 3,279 | 148 | 129,136 |

# APPENDIX A (cont.)

**Table E - Case EE2 Generation Mix (GWh)**

| | Coal | Nuclear | Gas | Oil | Renewable | Pumped Hydro | TOTAL |
|---|---|---|---|---|---|---|---|
| **2006** | 67,299 | 14,368 | 15,035 | 3,867 | 3,279 | 148 | 103,996 |
| **2007** | 67,299 | 14,368 | 9,061 | 2,340 | 3,279 | 148 | 96,495 |
| **2008** | 67,299 | 14,368 | 7,141 | 1,838 | 3,279 | 148 | 94,073 |
| **2009** | 67,299 | 14,368 | 6,456 | 1,660 | 3,279 | 148 | 93,210 |
| **2010** | 67,299 | 14,368 | 6,246 | 1,605 | 3,279 | 148 | 92,945 |
| **2011** | 67,299 | 14,368 | 7,166 | 1,883 | 3,279 | 148 | 94,143 |
| **2012** | 70,263 | 14,368 | 8,541 | 2,249 | 3,279 | 148 | 98,847 |
| **2013** | 70,263 | 14,368 | 10,658 | 2,788 | 3,279 | 148 | 101,504 |
| **2014** | 70,263 | 14,368 | 10,136 | 2,665 | 3,279 | 148 | 100,858 |
| **2015** | 71,981 | 14,368 | 10,279 | 2,737 | 3,279 | 148 | 102,792 |
| **2016** | 74,882 | 14,368 | 9,111 | 2,445 | 3,279 | 148 | 104,233 |
| **2017** | 76,342 | 14,368 | 9,618 | 2,589 | 3,279 | 148 | 106,343 |
| **2018** | 77,904 | 14,368 | 9,446 | 2,541 | 3,279 | 148 | 107,685 |
| **2019** | 79,981 | 14,368 | 9,314 | 2,503 | 3,279 | 148 | 109,593 |
| **2020** | 81,612 | 14,368 | 9,609 | 2,586 | 3,279 | 148 | 111,602 |
| **2021** | 85,389 | 14,368 | 8,562 | 2,303 | 3,279 | 148 | 114,048 |
| **2022** | 88,726 | 14,368 | 8,225 | 2,209 | 3,279 | 148 | 116,954 |
| **2023** | 89,852 | 14,368 | 9,643 | 2,642 | 3,279 | 148 | 119,933 |
| **2024** | 91,091 | 14,368 | 10,242 | 2,847 | 3,279 | 148 | 121,975 |
| **2025** | 91,353 | 14,368 | 10,784 | 3,073 | 3,279 | 148 | 123,005 |

**Table F - Case RPS1 Generation Mix (GWh)**

| | Coal | Nuclear | Gas | Oil | Renewable | Pumped Hydro | TOTAL |
|---|---|---|---|---|---|---|---|
| **2006** | 67,299 | 14,368 | 15,035 | 3,867 | 3,279 | 148 | 103,996 |
| **2007** | 67,299 | 14,368 | 9,121 | 2,355 | 3,521 | 148 | 96,812 |
| **2008** | 67,299 | 14,368 | 7,215 | 1,933 | 4,223 | 148 | 95,187 |
| **2009** | 67,299 | 14,368 | 6,547 | 1,747 | 4,749 | 148 | 94,859 |
| **2010** | 67,299 | 14,368 | 6,324 | 1,723 | 5,333 | 148 | 95,195 |
| **2011** | 67,299 | 14,368 | 8,760 | 2,409 | 5,934 | 148 | 98,919 |
| **2012** | 70,263 | 14,368 | 9,581 | 2,635 | 6,650 | 148 | 103,644 |
| **2013** | 73,226 | 14,368 | 10,721 | 2,916 | 7,271 | 148 | 108,650 |
| **2014** | 76,189 | 14,368 | 9,691 | 2,654 | 7,806 | 148 | 110,856 |
| **2015** | 77,908 | 14,368 | 9,574 | 2,628 | 8,332 | 148 | 112,958 |
| **2016** | 82,205 | 14,368 | 7,106 | 1,979 | 8,878 | 148 | 114,685 |
| **2017** | 83,884 | 14,368 | 7,832 | 2,152 | 8,987 | 148 | 117,371 |
| **2018** | 85,674 | 14,368 | 8,796 | 2,425 | 9,102 | 148 | 120,513 |
| **2019** | 90,053 | 14,368 | 9,030 | 2,495 | 9,233 | 148 | 125,327 |
| **2020** | 89,830 | 14,368 | 10,341 | 2,942 | 9,369 | 148 | 126,998 |
| **2021** | 93,842 | 14,368 | 9,685 | 2,762 | 9,493 | 148 | 130,299 |
| **2022** | 97,421 | 14,368 | 7,873 | 2,208 | 9,615 | 148 | 131,633 |
| **2023** | 100,865 | 14,368 | 7,765 | 2,195 | 9,754 | 148 | 135,095 |
| **2024** | 102,334 | 14,368 | 8,481 | 2,413 | 9,896 | 148 | 137,641 |
| **2025** | 102,824 | 14,368 | 9,491 | 2,608 | 10,019 | 148 | 139,458 |

# APPENDIX A (cont.)

**Table G - Case RPS2 Generation Mix (GWh)**

| | Coal | Nuclear | Gas | Oil | Renewable | Pumped Hydro | TOTAL |
|---|---|---|---|---|---|---|---|
| **2006** | 67,299 | 14,368 | 15,035 | 3,867 | 3,279 | 148 | 103,996 |
| **2007** | 67,299 | 14,368 | 9,121 | 2,355 | 3,521 | 148 | 96,812 |
| **2008** | 67,299 | 14,368 | 7,215 | 1,933 | 4,223 | 148 | 95,187 |
| **2009** | 67,299 | 14,368 | 6,547 | 1,747 | 4,749 | 148 | 94,859 |
| **2010** | 67,299 | 14,368 | 6,324 | 1,723 | 5,333 | 148 | 95,195 |
| **2011** | 67,299 | 14,368 | 8,760 | 2,409 | 5,934 | 148 | 98,919 |
| **2012** | 70,263 | 14,368 | 9,581 | 2,635 | 6,650 | 148 | 103,644 |
| **2013** | 73,226 | 14,368 | 10,721 | 2,916 | 7,271 | 148 | 108,650 |
| **2014** | 76,189 | 14,368 | 9,691 | 2,654 | 7,806 | 148 | 110,856 |
| **2015** | 77,908 | 14,368 | 9,574 | 2,628 | 8,332 | 148 | 112,958 |
| **2016** | 82,208 | 14,368 | 7,110 | 1,981 | 8,878 | 148 | 114,693 |
| **2017** | 82,526 | 14,368 | 7,977 | 2,191 | 10,065 | 148 | 117,274 |
| **2018** | 83,956 | 14,368 | 8,640 | 2,378 | 11,360 | 148 | 120,850 |
| **2019** | 87,962 | 14,368 | 8,629 | 2,375 | 12,702 | 148 | 126,184 |
| **2020** | 87,353 | 14,368 | 9,688 | 2,741 | 14,085 | 148 | 128,384 |
| **2021** | 90,945 | 14,368 | 8,620 | 2,443 | 15,538 | 148 | 132,062 |
| **2022** | 93,060 | 14,368 | 7,790 | 2,216 | 16,994 | 148 | 134,575 |
| **2023** | 96,074 | 14,368 | 5,586 | 1,579 | 18,485 | 148 | 136,240 |
| **2024** | 96,044 | 14,368 | 6,274 | 1,790 | 20,034 | 148 | 138,658 |
| **2025** | 96,050 | 14,368 | 6,671 | 1,839 | 21,631 | 148 | 140,706 |

**Table H - Case EE2RPS2 Generation Mix(GWh)**

| | Coal | Nuclear | Gas | Oil | Renewable | Pumped Hydro | TOTAL |
|---|---|---|---|---|---|---|---|
| **2006** | 67,299 | 14,368 | 15,035 | 3,867 | 3,279 | 148 | 103,996 |
| **2007** | 67,299 | 14,368 | 9,054 | 2,338 | 3,521 | 148 | 96,729 |
| **2008** | 67,299 | 14,368 | 7,081 | 1,823 | 4,223 | 148 | 94,943 |
| **2009** | 67,299 | 14,368 | 6,363 | 1,635 | 4,749 | 148 | 94,563 |
| **2010** | 67,299 | 14,368 | 6,112 | 1,570 | 5,333 | 148 | 94,830 |
| **2011** | 67,299 | 14,368 | 6,833 | 1,775 | 5,934 | 148 | 96,358 |
| **2012** | 70,263 | 14,368 | 8,325 | 2,149 | 6,650 | 148 | 101,902 |
| **2013** | 73,226 | 14,368 | 8,983 | 2,313 | 7,271 | 148 | 106,309 |
| **2014** | 73,226 | 14,368 | 8,444 | 2,181 | 7,806 | 148 | 106,173 |
| **2015** | 73,463 | 14,368 | 8,906 | 2,304 | 8,332 | 148 | 107,521 |
| **2016** | 75,381 | 14,368 | 8,273 | 2,143 | 8,878 | 148 | 109,191 |
| **2017** | 76,903 | 14,368 | 8,342 | 2,162 | 8,987 | 148 | 110,910 |
| **2018** | 80,614 | 14,368 | 8,172 | 2,116 | 9,102 | 148 | 114,520 |
| **2019** | 82,759 | 14,368 | 8,132 | 2,105 | 9,233 | 148 | 116,747 |
| **2020** | 84,454 | 14,368 | 8,188 | 2,120 | 9,369 | 148 | 118,648 |
| **2021** | 86,224 | 14,368 | 7,922 | 2,078 | 9,493 | 148 | 120,233 |
| **2022** | 89,634 | 14,368 | 7,624 | 1,998 | 9,615 | 148 | 123,387 |
| **2023** | 92,910 | 14,368 | 8,268 | 2,175 | 9,754 | 148 | 127,624 |
| **2024** | 94,227 | 14,368 | 8,890 | 2,344 | 9,896 | 148 | 129,874 |
| **2025** | 94,574 | 14,368 | 9,497 | 2,571 | 10,019 | 148 | 131,177 |

# APPENDIX A (cont.)

**Table I - Case EE2RPS2 Generation Mix (GWh)**

| | Coal | Nuclear | Gas | Oil | Renewable | Pumped Hydro | TOTAL |
|---|---|---|---|---|---|---|---|
| **2006** | 67,299 | 14,368 | 15,035 | 3,867 | 3,279 | 148 | 103,996 |
| **2007** | 67,299 | 14,368 | 9,039 | 2,334 | 3,521 | 148 | 96,709 |
| **2008** | 67,299 | 14,368 | 7,033 | 1,810 | 4,223 | 148 | 94,882 |
| **2009** | 67,299 | 14,368 | 6,288 | 1,616 | 4,749 | 148 | 94,468 |
| **2010** | 67,299 | 14,368 | 6,009 | 1,543 | 5,333 | 148 | 94,701 |
| **2011** | 67,299 | 14,368 | 6,278 | 1,613 | 5,934 | 148 | 95,641 |
| **2012** | 68,781 | 14,368 | 8,325 | 2,169 | 6,650 | 148 | 100,442 |
| **2013** | 68,781 | 14,368 | 9,850 | 2,556 | 7,271 | 148 | 102,974 |
| **2014** | 68,781 | 14,368 | 9,018 | 2,352 | 7,806 | 148 | 102,473 |
| **2015** | 69,018 | 14,368 | 9,350 | 2,468 | 8,332 | 148 | 103,684 |
| **2016** | 71,084 | 14,368 | 8,541 | 2,262 | 8,878 | 148 | 105,281 |
| **2017** | 72,168 | 14,368 | 8,812 | 2,337 | 10,065 | 148 | 107,898 |
| **2018** | 73,325 | 14,368 | 8,407 | 2,225 | 11,360 | 148 | 109,833 |
| **2019** | 72,905 | 14,368 | 8,527 | 2,280 | 12,702 | 148 | 110,931 |
| **2020** | 74,096 | 14,368 | 8,648 | 2,315 | 14,085 | 148 | 113,661 |
| **2021** | 77,405 | 14,368 | 7,616 | 2,035 | 15,538 | 148 | 117,111 |
| **2022** | 79,234 | 14,368 | 7,611 | 2,037 | 16,994 | 148 | 120,392 |
| **2023** | 79,879 | 14,368 | 7,577 | 2,038 | 18,485 | 148 | 122,495 |
| **2024** | 79,579 | 14,368 | 8,036 | 2,218 | 20,034 | 148 | 124,384 |
| **2025** | 79,322 | 14,368 | 8,150 | 2,280 | 21,631 | 148 | 125,899 |

# APPENDIX B – Michigan Economic Impact Tables

**Table J – REMI Projected Michigan Gross State Product**

| | BASE CASE | EE1 | | | EE2 | | | RPS1 | | | RPS2 | | | EE1RPS1 | | | EE2RPS2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Case | | | Case | | | Case | | | Case | | | Case | | | Case | |
| | TOTAL ($Bil) | TOTAL ($Bil) | ($,Mil) | PERCENT | TOTAL ($Bil) | ($,Mil) | PERCENT | TOTAL ($Bil) | ($,Mil) | PERCENT | TOTAL ($Bil) | ($,Mil) | PERCENT | TOTAL ($Bil) | ($,Mil) | PERCENT | TOTAL ($Bil) | ($,Mil) | PERCENT |
| 2006 | $391.89 | $391.89 | $0.00 | 0.000% | $391.89 | $0.00 | 0.000% | $391.89 | $5.95 | 0.002% | $391.89 | $5.95 | 0.002% | $391.89 | $5.95 | 0.002% | $391.89 | $5.95 | 0.002% |
| 2007 | $407.83 | $407.86 | $30.30 | 0.007% | $407.87 | $34.85 | 0.009% | $407.86 | $28.56 | 0.007% | $407.86 | $28.56 | 0.007% | $407.89 | $58.69 | 0.014% | $407.90 | $66.07 | 0.016% |
| 2008 | $423.16 | $423.19 | $28.93 | 0.007% | $423.18 | $19.62 | 0.005% | $423.20 | $37.29 | 0.009% | $423.20 | $37.29 | 0.009% | $423.23 | $69.40 | 0.016% | $423.22 | $62.87 | 0.015% |
| 2009 | $437.21 | $437.24 | $23.32 | 0.005% | $437.22 | $10.56 | 0.002% | $437.25 | $35.43 | 0.008% | $437.25 | $35.43 | 0.008% | $437.27 | $58.14 | 0.013% | $437.27 | $51.48 | 0.012% |
| 2010 | $451.04 | $451.07 | $30.21 | 0.007% | $451.06 | $18.34 | 0.004% | $451.08 | $42.36 | 0.009% | $451.08 | $42.36 | 0.009% | $451.10 | $61.22 | 0.014% | $451.09 | $51.51 | 0.011% |
| 2011 | $464.15 | $464.17 | $22.95 | 0.005% | $464.16 | $15.17 | 0.003% | $464.20 | $56.00 | 0.012% | $464.20 | $56.00 | 0.012% | $464.21 | $67.02 | 0.014% | $464.21 | $64.70 | 0.014% |
| 2012 | $477.09 | $477.11 | $26.64 | 0.006% | $477.10 | $14.86 | 0.003% | $477.15 | $60.67 | 0.013% | $477.14 | $53.25 | 0.011% | $477.16 | $77.48 | 0.016% | $477.16 | $75.71 | 0.016% |
| 2013 | $486.89 | $486.93 | $42.72 | 0.009% | $486.91 | $21.76 | 0.004% | $486.93 | $43.12 | 0.009% | $486.93 | $35.40 | 0.007% | $486.97 | $83.31 | 0.017% | $486.95 | $60.52 | 0.012% |
| 2014 | $496.85 | $496.88 | $31.10 | 0.006% | $496.88 | $31.16 | 0.006% | $496.89 | $36.47 | 0.007% | $496.88 | $28.63 | 0.006% | $496.91 | $61.28 | 0.012% | $496.89 | $42.60 | 0.009% |
| 2015 | $506.84 | $506.90 | $54.81 | 0.011% | $506.91 | $61.68 | 0.012% | $506.86 | $19.56 | 0.004% | $506.86 | $11.63 | 0.002% | $506.92 | $76.60 | 0.015% | $506.90 | $60.94 | 0.012% |
| 2016 | $515.75 | $515.80 | $42.60 | 0.008% | $515.82 | $71.04 | 0.014% | $515.75 | ($3.66) | (0.001%) | $515.80 | $50.72 | 0.010% | $515.80 | $48.58 | 0.009% | $515.87 | $113.80 | 0.022% |
| 2017 | $524.46 | $524.53 | $70.86 | 0.014% | $524.57 | $110.20 | 0.021% | $524.43 | ($31.80) | (0.006%) | $524.54 | $79.22 | 0.015% | $524.51 | $48.95 | 0.009% | $524.64 | $181.90 | 0.035% |
| 2018 | $533.07 | $533.16 | $89.48 | 0.017% | $533.19 | $117.00 | 0.022% | $533.03 | ($40.71) | (0.008%) | $533.15 | $80.02 | 0.015% | $533.13 | $60.79 | 0.011% | $533.26 | $184.10 | 0.035% |
| 2019 | $541.71 | $541.79 | $83.92 | 0.015% | $541.84 | $131.80 | 0.024% | $541.67 | ($41.02) | (0.008%) | $541.78 | $66.71 | 0.012% | $541.76 | $49.68 | 0.009% | $541.88 | $170.10 | 0.031% |
| 2020 | $550.30 | $550.42 | $117.40 | 0.021% | $550.47 | $164.30 | 0.030% | $550.25 | ($52.06) | (0.009%) | $550.35 | $46.51 | 0.008% | $550.38 | $75.32 | 0.014% | $550.50 | $195.10 | 0.035% |

# Appendix B (cont.)

**Table K – REMI Projected Michigan Employment Levels**

| | BASE CASE | EE1 | | | EE2 | | | RPS1 | | | RPS2 | | | EE1RPS1 | | | EE2RPS2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Difference from Base Case | | | Difference from Base Case | | | Difference from Base Case | | | Difference from Base Case | | | Difference from Base Case | | | Difference from Base Case | |
| | TOTAL (,000) | TOTAL (,000) | CHANGE | PERCENT | TOTAL (,000) | CHANGE | PERCENT | TOTAL (,000) | CHANGE | PERCENT | TOTAL (,000) | CHANGE | PERCENT | TOTAL (,000) | CHANGE | PERCENT | TOTAL (,000) | CHANGE | PERCENT |
| 2006 | 5,604.7 | 5,604.7 | 0 | 0.000% | 5,604.7 | 0 | 0.000% | 5,604.7 | 0 | 0.000% | 5,604.7 | 0 | 0.000% | 5,604.7 | 0 | 0.000% | 5,604.7 | 0 | 0.000% |
| 2007 | 5,667.8 | 5,668.1 | 322 | 0.006% | 5,668.3 | 540 | 0.010% | 5,668.2 | 420 | 0.007% | 5,668.2 | 420 | 0.007% | 5,668.5 | 743 | 0.013% | 5,668.6 | 834 | 0.015% |
| 2008 | 5,713.8 | 5,714.2 | 363 | 0.006% | 5,714.2 | 357 | 0.006% | 5,714.3 | 504 | 0.009% | 5,714.3 | 504 | 0.009% | 5,714.8 | 928 | 0.016% | 5,714.6 | 792 | 0.014% |
| 2009 | 5,748.0 | 5,748.2 | 260 | 0.005% | 5,748.2 | 208 | 0.004% | 5,748.4 | 482 | 0.008% | 5,748.4 | 482 | 0.008% | 5,748.7 | 715 | 0.012% | 5,748.6 | 592 | 0.010% |
| 2010 | 5,776.0 | 5,776.4 | 397 | 0.007% | 5,776.4 | 385 | 0.007% | 5,776.5 | 498 | 0.009% | 5,776.5 | 498 | 0.009% | 5,776.7 | 724 | 0.013% | 5,776.6 | 558 | 0.010% |
| 2011 | 5,798.3 | 5,798.6 | 270 | 0.005% | 5,798.6 | 320 | 0.006% | 5,799.0 | 651 | 0.011% | 5,799.0 | 651 | 0.011% | 5,799.0 | 727 | 0.013% | 5,799.0 | 716 | 0.012% |
| 2012 | 5,814.4 | 5,814.7 | 274 | 0.005% | 5,814.8 | 348 | 0.006% | 5,815.1 | 630 | 0.011% | 5,815.0 | 514 | 0.009% | 5,815.2 | 780 | 0.013% | 5,815.2 | 771 | 0.013% |
| 2013 | 5,850.5 | 5,851.0 | 531 | 0.009% | 5,850.9 | 386 | 0.007% | 5,850.9 | 418 | 0.007% | 5,850.8 | 297 | 0.005% | 5,851.4 | 906 | 0.015% | 5,851.2 | 693 | 0.012% |
| 2014 | 5,884.6 | 5,885.0 | 398 | 0.007% | 5,885.1 | 548 | 0.009% | 5,884.9 | 340 | 0.006% | 5,884.8 | 218 | 0.004% | 5,885.2 | 648 | 0.011% | 5,885.1 | 512 | 0.009% |
| 2015 | 5,917.0 | 5,917.7 | 707 | 0.012% | 5,918.0 | 935 | 0.016% | 5,917.1 | 83 | 0.001% | 5,917.0 | (39) | (0.001%) | 5,917.9 | 886 | 0.015% | 5,917.9 | 843 | 0.014% |
| 2016 | 5,935.2 | 5,935.8 | 628 | 0.011% | 5,936.4 | 1,158 | 0.020% | 5,935.0 | (180) | (0.003%) | 5,935.7 | 451 | 0.008% | 5,935.8 | 635 | 0.011% | 5,936.9 | 1,662 | 0.028% |
| 2017 | 5,949.8 | 5,950.8 | 999 | 0.017% | 5,951.4 | 1,594 | 0.027% | 5,949.4 | (452) | (0.008%) | 5,950.6 | 713 | 0.012% | 5,950.6 | 756 | 0.013% | 5,952.2 | 2,382 | 0.040% |
| 2018 | 5,961.6 | 5,962.7 | 1,144 | 0.019% | 5,963.1 | 1,571 | 0.026% | 5,961.0 | (511) | (0.009%) | 5,962.3 | 733 | 0.012% | 5,962.4 | 875 | 0.015% | 5,963.9 | 2,349 | 0.039% |
| 2019 | 5,972.6 | 5,973.7 | 1,107 | 0.019% | 5,974.3 | 1,728 | 0.029% | 5,972.2 | (427) | (0.007%) | 5,973.2 | 580 | 0.010% | 5,973.4 | 827 | 0.014% | 5,974.8 | 2,173 | 0.036% |
| 2020 | 5,982.2 | 5,983.6 | 1,381 | 0.023% | 5,984.2 | 1,979 | 0.033% | 5,981.7 | (436) | (0.007%) | 5,982.5 | 358 | 0.006% | 5,983.2 | 1,054 | 0.018% | 5,984.5 | 2,313 | 0.039% |

# Appendix B (cont.)

### Table L - REMI Projected Michigan Disposable Personal Income

| | BASE CASE | EE1 | | | EE2 | | | RPS1 | | | RPS2 | | | EE1RPS1 | | | EE2RPS2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Difference from Base Case | | | Difference from Base Case | | | Difference from Base Case | | | Difference from Base Case | | | Difference from Base Case | | | Difference from Base Case | |
| | TOTAL ($Bil) | TOTAL ($Bil) | CHANGE ($,Mil) | PERCENT | TOTAL ($Bil) | CHANGE ($,Mil) | PERCENT | TOTAL ($Bil) | CHANGE ($,Mil) | PERCENT | TOTAL ($Bil) | CHANGE ($,Mil) | PERCENT | TOTAL ($Bil) | CHANGE ($,Mil) | PERCENT | TOTAL ($Bil) | CHANGE ($,Mil) | PERCENT |
| 2006 | $293.80 | $293.80 | $0.00 | 0.000% | $293.80 | $0.00 | 0.000% | $293.80 | $0.00 | 0.000% | $293.80 | $0.00 | 0.000% | $293.80 | $0.00 | 0.000% | $293.80 | $0.00 | 0.000% |
| 2007 | $305.21 | $305.22 | $11.72 | 0.004% | $305.23 | $22.67 | 0.007% | $305.22 | $12.57 | 0.004% | $305.22 | $13.31 | 0.004% | $305.23 | $24.41 | 0.008% | $305.24 | $31.34 | 0.010% |
| 2008 | $313.67 | $313.69 | $23.10 | 0.007% | $313.70 | $28.66 | 0.009% | $313.68 | $12.97 | 0.004% | $313.68 | $13.98 | 0.004% | $313.71 | $38.12 | 0.012% | $313.71 | $39.22 | 0.013% |
| 2009 | $321.35 | $321.37 | $20.94 | 0.007% | $321.37 | $26.25 | 0.008% | $321.36 | $13.95 | 0.004% | $321.36 | $14.43 | 0.004% | $321.38 | $32.04 | 0.010% | $321.38 | $34.42 | 0.011% |
| 2010 | $328.75 | $328.78 | $31.19 | 0.009% | $328.79 | $40.10 | 0.012% | $328.76 | $7.42 | 0.002% | $328.76 | $9.37 | 0.003% | $328.78 | $34.42 | 0.010% | $328.78 | $35.95 | 0.011% |
| 2011 | $335.97 | $335.99 | $29.88 | 0.009% | $336.00 | $39.79 | 0.012% | $335.97 | $9.80 | 0.003% | $335.98 | $12.88 | 0.004% | $336.00 | $32.41 | 0.010% | $336.01 | $41.02 | 0.012% |
| 2012 | $342.82 | $342.85 | $31.98 | 0.009% | $342.87 | $43.15 | 0.013% | $342.82 | ($0.52) | 0.000% | $342.82 | $0.09 | 0.000% | $342.85 | $28.14 | 0.008% | $342.85 | $31.62 | 0.009% |
| 2013 | $349.15 | $349.20 | $46.57 | 0.013% | $349.21 | $53.59 | 0.015% | $349.14 | ($9.40) | (0.003%) | $349.14 | ($8.88) | (0.003%) | $349.19 | $33.14 | 0.009% | $349.19 | $35.06 | 0.010% |
| 2014 | $355.78 | $355.83 | $46.14 | 0.013% | $355.84 | $63.11 | 0.018% | $355.76 | ($17.88) | (0.005%) | $355.76 | ($16.30) | (0.005%) | $355.80 | $23.56 | 0.007% | $355.81 | $28.87 | 0.008% |
| 2015 | $362.60 | $362.65 | $57.43 | 0.016% | $362.68 | $82.24 | 0.023% | $362.56 | ($34.58) | (0.010%) | $362.56 | ($31.92) | (0.009%) | $362.62 | $27.37 | 0.008% | $362.64 | $41.81 | 0.012% |
| 2016 | $369.21 | $369.28 | $68.60 | 0.019% | $369.33 | $112.90 | 0.031% | $369.16 | ($49.35) | (0.013%) | $369.20 | ($16.57) | (0.004%) | $369.24 | $24.69 | 0.007% | $369.30 | $87.40 | 0.024% |
| 2017 | $375.99 | $376.08 | $91.09 | 0.024% | $376.13 | $140.20 | 0.037% | $375.92 | ($61.19) | (0.016%) | $375.97 | ($17.94) | (0.005%) | $376.02 | $38.27 | 0.010% | $376.10 | $111.10 | 0.030% |
| 2018 | $382.81 | $382.91 | $103.00 | 0.027% | $382.96 | $151.40 | 0.040% | $382.74 | ($67.57) | (0.018%) | $382.78 | ($24.23) | (0.006%) | $382.86 | $47.73 | 0.012% | $382.92 | $114.50 | 0.030% |
| 2019 | $389.82 | $389.94 | $117.30 | 0.030% | $389.99 | $170.20 | 0.044% | $389.76 | ($66.68) | (0.017%) | $389.79 | ($37.51) | (0.010%) | $389.88 | $60.30 | 0.015% | $389.93 | $107.30 | 0.028% |
| 2020 | $396.94 | $397.06 | $120.90 | 0.030% | $397.12 | $180.40 | 0.045% | $396.87 | ($66.62) | (0.017%) | $396.88 | ($57.89) | (0.015%) | $397.00 | $61.95 | 0.016% | $397.03 | $92.25 | 0.023% |

# Appendix B (cont.)

## Table M - REMI Projected Michigan Personal Income (per capita basis)

| | BASE CASE | | EE1 | | | | EE2 | | | | RPS1 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Per Capita Income | | | | Per Capita Income | | | | Per Capita Income | | |
| | Population (thous) | Per Capita Income | Population (thous) | Projected | Change | Percent Change | Population (thous) | Projected | Change | Percent Change | Population (thous) | Projected | Change | Percent Change |
| 2006 | 10,114 | $29,047 | 10,114 | $29,047 | $0.00 | 0.000% | 10,114 | $29,047 | $0.00 | 0.000% | 10,114 | $29,048 | $0.23 | 0.001% |
| 2007 | 10,134 | $30,119 | 10,134 | $30,120 | $0.95 | 0.003% | 10,134 | $30,121 | $1.86 | 0.006% | 10,134 | $30,120 | $0.94 | 0.003% |
| 2008 | 10,156 | $30,885 | 10,156 | $30,887 | $1.76 | 0.006% | 10,156 | $30,887 | $2.11 | 0.007% | 10,156 | $30,886 | $0.75 | 0.002% |
| 2009 | 10,181 | $31,565 | 10,181 | $31,566 | $1.33 | 0.004% | 10,181 | $31,566 | $1.64 | 0.005% | 10,181 | $31,565 | $0.64 | 0.002% |
| 2010 | 10,206 | $32,210 | 10,207 | $32,212 | $1.99 | 0.006% | 10,207 | $32,212 | $2.58 | 0.008% | 10,207 | $32,210 | ($0.10) | 0.000% |
| 2011 | 10,233 | $32,833 | 10,233 | $32,834 | $1.61 | 0.005% | 10,233 | $32,835 | $2.20 | 0.007% | 10,233 | $32,833 | ($0.03) | 0.000% |
| 2012 | 10,259 | $33,416 | 10,260 | $33,417 | $1.57 | 0.005% | 10,260 | $33,418 | $2.18 | 0.007% | 10,260 | $33,415 | ($1.04) | (0.003%) |
| 2013 | 10,293 | $33,920 | 10,294 | $33,923 | $2.53 | 0.007% | 10,294 | $33,923 | $2.75 | 0.008% | 10,294 | $33,918 | ($1.74) | (0.005%) |
| 2014 | 10,334 | $34,428 | 10,335 | $34,430 | $2.14 | 0.006% | 10,335 | $34,431 | $3.12 | 0.009% | 10,334 | $34,425 | ($2.33) | (0.007%) |
| 2015 | 10,380 | $34,932 | 10,381 | $34,934 | $2.70 | 0.008% | 10,381 | $34,936 | $4.16 | 0.012% | 10,380 | $34,928 | ($3.47) | (0.010%) |
| 2016 | 10,431 | $35,396 | 10,432 | $35,400 | $3.21 | 0.009% | 10,432 | $35,402 | $6.00 | 0.017% | 10,431 | $35,392 | ($4.28) | (0.012%) |
| 2017 | 10,486 | $35,856 | 10,487 | $35,860 | $4.52 | 0.013% | 10,488 | $35,863 | $7.24 | 0.020% | 10,486 | $35,851 | ($4.69) | (0.013%) |
| 2018 | 10,545 | $36,303 | 10,546 | $36,307 | $4.79 | 0.013% | 10,547 | $36,310 | $7.05 | 0.019% | 10,544 | $36,298 | ($4.61) | (0.013%) |
| 2019 | 10,607 | $36,751 | 10,609 | $36,756 | $5.24 | 0.014% | 10,610 | $36,759 | $7.50 | 0.020% | 10,606 | $36,747 | ($3.99) | (0.011%) |
| 2020 | 10,672 | $37,196 | 10,674 | $37,200 | $4.70 | 0.013% | 10,675 | $37,203 | $7.15 | 0.019% | 10,671 | $37,192 | ($3.54) | (0.010%) |

| | RPS2 | | | | EE1RPS1 | | | | EE2RPS2 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Per Capita Income | | | | Per Capita Income | | | | Per Capita Income | | |
| | Population (thous) | Projected | Change | Percent Change | Population (thous) | Projected | Change | Percent Change | Population (thous) | Projected | Change | Percent Change |
| 2006 | 10,114 | $29,048 | $0.24 | 0.001% | 10,114 | $29,048 | $0.23 | 0.001% | 10,114 | $29,048 | $0.23 | 0.001% |
| 2007 | 10,134 | $30,120 | $1.01 | 0.003% | 10,134 | $30,121 | $1.91 | 0.006% | 10,134 | $30,121 | $2.49 | 0.008% |
| 2008 | 10,156 | $30,886 | $0.84 | 0.003% | 10,156 | $30,888 | $2.67 | 0.009% | 10,156 | $30,888 | $2.72 | 0.009% |
| 2009 | 10,181 | $31,565 | $0.68 | 0.002% | 10,181 | $31,566 | $1.71 | 0.005% | 10,181 | $31,566 | $1.90 | 0.006% |
| 2010 | 10,207 | $32,210 | $0.09 | 0.000% | 10,207 | $32,211 | $1.59 | 0.005% | 10,207 | $32,212 | $1.72 | 0.005% |
| 2011 | 10,233 | $32,833 | $0.27 | 0.001% | 10,233 | $32,834 | $1.11 | 0.003% | 10,233 | $32,835 | $1.81 | 0.006% |
| 2012 | 10,260 | $33,415 | ($0.90) | -0.003% | 10,260 | $33,416 | $0.47 | 0.001% | 10,260 | $33,416 | $0.64 | 0.002% |
| 2013 | 10,294 | $33,919 | ($1.54) | -0.005% | 10,294 | $33,921 | $0.67 | 0.002% | 10,294 | $33,921 | $0.72 | 0.002% |
| 2014 | 10,334 | $34,426 | ($1.97) | -0.006% | 10,335 | $34,427 | ($0.33) | (0.001%) | 10,335 | $34,428 | ($0.00) | 0.000% |
| 2015 | 10,380 | $34,929 | ($2.96) | -0.008% | 10,381 | $34,932 | ($0.16) | 0.000% | 10,381 | $34,933 | $0.87 | 0.002% |
| 2016 | 10,431 | $35,395 | ($1.37) | -0.004% | 10,432 | $35,396 | ($0.50) | (0.001%) | 10,432 | $35,401 | $4.15 | 0.012% |
| 2017 | 10,486 | $35,854 | ($1.42) | -0.004% | 10,487 | $35,856 | $0.53 | 0.001% | 10,488 | $35,861 | $5.03 | 0.014% |
| 2018 | 10,545 | $36,301 | ($1.85) | -0.005% | 10,546 | $36,304 | $1.06 | 0.003% | 10,547 | $36,307 | $4.19 | 0.012% |
| 2019 | 10,607 | $36,748 | ($2.74) | -0.007% | 10,608 | $36,753 | $1.80 | 0.005% | 10,609 | $36,754 | $2.66 | 0.007% |
| 2020 | 10,671 | $37,192 | ($4.04) | -0.011% | 10,673 | $37,197 | $1.49 | 0.004% | 10,674 | $37,196 | $0.64 | 0.002% |

# APPENDIX C – Projected $CO_2$ Emissions

**Table N - CO2 Emissions**

| | BASE CASE | EE1 | | | EE2 | | | RPS1 | | | RPS2 | | | EE1RPS1 | | | EE2RPS2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TOTAL | TOTAL | Difference from Base Case | | TOTAL | Difference from Base Case | | TOTAL | Difference from Base Case | | TOTAL | Difference from Base Case | | TOTAL | Difference from Base Case | | TOTAL | Difference from Base Case | |
| | (Kilotons) | (Kilotons) | REDUCTION (ktons/Year) | PERCENT | (Kilotons) | REDUCTION (ktons/Year) | PERCENT | (Kilotons) | REDUCTION (ktons/Year) | PERCENT | (Kilotons) | REDUCTION (ktons/Year) | PERCENT | (Kilotons) | REDUCTION (ktons/Year) | PERCENT | (Kilotons) | REDUCTION (ktons/Year) | PERCENT |
| **2006** | 188,737 | 188,737 | 0 | 0.00% | 188,737 | 0 | 0.00% | 188,738 | 0 | 0.00% | 188,738 | 0 | 0.00% | 188,738 | 0 | 0.00% | 188,738 | 0 | 0.00% |
| **2007** | 189,480 | 189,426 | 54 | 0.03% | 189,416 | 64 | 0.03% | 189,465 | 15 | 0.01% | 189,465 | 15 | 0.01% | 189,413 | 68 | 0.04% | 189,400 | 80 | 0.04% |
| **2008** | 191,376 | 191,219 | 157 | 0.08% | 191,173 | 203 | 0.11% | 191,278 | 98 | 0.05% | 191,278 | 98 | 0.05% | 191,121 | 255 | 0.13% | 191,073 | 302 | 0.16% |
| **2009** | 193,947 | 193,723 | 225 | 0.12% | 193,646 | 301 | 0.16% | 193,775 | 173 | 0.09% | 193,775 | 173 | 0.09% | 193,553 | 394 | 0.20% | 193,475 | 472 | 0.24% |
| **2010** | 194,212 | 194,040 | 172 | 0.09% | 193,933 | 279 | 0.14% | 194,060 | 152 | 0.08% | 194,060 | 152 | 0.08% | 193,793 | 419 | 0.22% | 193,595 | 617 | 0.32% |
| **2011** | 196,729 | 195,029 | 1,700 | 0.86% | 194,610 | 2,119 | 1.08% | 196,100 | 629 | 0.32% | 196,100 | 629 | 0.32% | 194,325 | 2,405 | 1.22% | 193,933 | 2,797 | 1.42% |
| **2012** | 199,032 | 198,704 | 328 | 0.16% | 197,529 | 1,503 | 0.76% | 198,599 | 434 | 0.22% | 198,597 | 435 | 0.22% | 197,279 | 1,754 | 0.88% | 196,175 | 2,857 | 1.44% |
| **2013** | 201,293 | 199,867 | 1,426 | 0.71% | 197,908 | 3,385 | 1.68% | 200,417 | 876 | 0.44% | 200,415 | 878 | 0.44% | 198,775 | 2,519 | 1.25% | 196,108 | 5,186 | 2.58% |
| **2014** | 203,119 | 199,749 | 3,369 | 1.66% | 197,685 | 5,434 | 2.68% | 201,820 | 1,299 | 0.64% | 201,819 | 1,300 | 0.64% | 198,394 | 4,724 | 2.33% | 195,517 | 7,602 | 3.74% |
| **2015** | 204,514 | 201,234 | 3,280 | 1.60% | 199,125 | 5,389 | 2.63% | 202,987 | 1,526 | 0.75% | 202,986 | 1,528 | 0.75% | 198,949 | 5,565 | 2.72% | 195,997 | 8,517 | 4.16% |
| **2016** | 207,480 | 203,030 | 4,450 | 2.14% | 200,779 | 6,702 | 3.23% | 204,601 | 2,879 | 1.39% | 204,615 | 2,866 | 1.38% | 200,132 | 7,348 | 3.54% | 197,224 | 10,256 | 4.94% |
| **2017** | 209,134 | 205,285 | 3,849 | 1.84% | 202,750 | 6,384 | 3.05% | 206,295 | 2,839 | 1.36% | 205,398 | 3,736 | 1.79% | 201,429 | 7,706 | 3.68% | 198,357 | 10,777 | 5.15% |
| **2018** | 211,751 | 207,619 | 4,132 | 1.95% | 204,066 | 7,684 | 3.63% | 209,143 | 2,608 | 1.23% | 207,667 | 4,084 | 1.93% | 204,226 | 7,525 | 3.55% | 199,363 | 12,387 | 5.85% |
| **2019** | 215,810 | 209,942 | 5,867 | 2.72% | 206,239 | 9,571 | 4.43% | 212,934 | 2,875 | 1.33% | 210,886 | 4,924 | 2.28% | 206,923 | 8,887 | 4.12% | 199,960 | 15,850 | 7.34% |
| **2020** | 218,735 | 211,768 | 6,968 | 3.19% | 207,912 | 10,824 | 4.95% | 214,894 | 3,842 | 1.76% | 212,252 | 6,484 | 2.96% | 208,534 | 10,202 | 4.66% | 201,082 | 17,654 | 8.07% |

# APPENDIX D – REMI INPUT FRACTIONS

**Table O – Capital Cost Fractions**

| | COAL | | GAS PEAKER | | GAS COMBINED CYCLE | | WIND | | BIOMASS | | ANAEROBIC DIGESTION | | LANDFGILL GAS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | In-State | Total | In-State | Total | In-State | Total | In-State | Total | In-State | Total | In-State | Total | In-State |
| Forestry et al. | | | | | | | | | | | | | | |
| Agriculture | | | | | | | | | | | | | | |
| Oil, gas extraction | 0.30% | | 0.30% | | | | | | | | | | | |
| Mining (except oil, gas) | | | | | | | | | | | | | | |
| Support activities for mining | | | | | | | | | | | | | | |
| Utilities | 1.00% | 1.00% | | | | | | | | | | | | |
| Construction | 27.00% | 18.00% | 13.00% | 10.40% | 16.00% | 12.80% | 13.50% | 12.15% | 20.00% | 20.00% | 20.00% | 20.00% | 20.00% | 20.00% |
| Wood product mfg | 1.00% | | | | | | | | | | | | | |
| Nonmetallic mineral prod mfg | | | | | | | | | | | | | | |
| Primary metal mfg | 10.00% | | 15.00% | | 18.00% | | 14.40% | 2.88% | 10.00% | | 10.00% | | 10.00% | |
| Fabricated metal prod mfg | 30.00% | | 49.60% | | 42.00% | | 37.20% | 3.72% | 27.00% | 5.40% | 27.00% | 5.40% | 27.00% | 5.40% |
| Machinery mfg | | | | | | | | | | | | | | |
| Computer, electronic prod mfg | 2.00% | | 1.00% | | 2.00% | | 0.90% | | 3.00% | | 3.00% | | 3.00% | |
| Electrical equip, appliance mfg | | | | | | | 16.50% | 5.00% | 20.00% | | 20.00% | | 20.00% | |
| Motor vehicle mfg | | | | | | | | | | | | | | |
| Transp equip mfg, exc. motor veh | | | | | | | | | | | | | | |
| Furniture, related prod mfg | | | | | | | | | | | | | | |
| Miscellaneous mfg | | | | | | | | | | | | | | |
| Food mfg | | | | | | | | | | | | | | |
| Beverage, tobacco prod mfg | | | | | | | | | | | | | | |
| Textile mills | | | | | | | | | | | | | | |
| Textile prod mills | | | | | | | | | | | | | | |
| Apparel mfg | | | | | | | | | | | | | | |
| Leather, allied prod mfg | | | | | | | | | | | | | | |
| Paper mfg | | | | | | | | | | | | | | |
| Printing, rel supp act | | | | | | | | | | | | | | |
| Petroleum, coal prod mfg | | | | | | | | | | | | | | |
| Chemical mfg | 3.00% | 0.60% | 0.20% | 0.04% | 0.60% | 0.12% | | | 1.00% | | 1.00% | | 1.00% | |
| Plastics, rubber prod mfg | 2.00% | 0.40% | 0.20% | 0.04% | 0.40% | 0.08% | | | | | | | | |
| Wholesale trade | | | | | | | | | | | | | | |
| Retail trade | | | | | | | | | | | | | | |
| Air transportation | | | | | | | | | | | | | | |
| Rail transportation | 2.00% | 1.00% | 2.00% | 1.00% | 2.00% | 1.00% | | | | | | | | |
| Water transportation | | | | | | | | | | | | | | |
| Truck transp; Couriers, msngrs | 2.00% | 1.00% | 2.00% | 1.00% | 2.00% | 1.00% | 1.00% | 0.50% | 1.00% | 0.50% | 1.00% | 0.50% | 1.00% | 0.50% |
| Transit, ground pass transp | | | | | | | | | | | | | | |
| Pipeline transportation | | | | | | | | | | | | | | |
| Scenic, sightseeing transp; supp | | | | | | | | | | | | | | |
| Warehousing, storage | 2.00% | 2.00% | | | | | 0.90% | 0.90% | | | | | | |
| Publishing, exc Internet | | | | | | | | | | | | | | |
| Motion picture, sound rec | | | | | | | | | | | | | | |
| Internet serv, data proc, other | | | | | | | | | | | | | | |
| Broadcasting, exc Int; Telecomm | | | | | | | | 0.00% | | | | | | |
| Monetary authorities, et al. | 2.60% | | 2.60% | | 2.60% | | 3.00% | | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% |
| Sec, comm contracts, inv | | | | | | | | | | | | | | |
| Ins carriers, rel act | | | | | | | | | | | | | | |
| Real estate | 0.40% | 0.40% | 0.10% | 0.10% | 0.10% | 0.10% | 1.00% | 1.00% | | | | | | |
| Rental, leasing services | | | | | | | | | | | | | | |
| Prof, tech services | 6.30% | 1.89% | 2.00% | 0.80% | 2.00% | 0.80% | 4.30% | 4.30% | 5.00% | 5.00% | 5.00% | 5.00% | 5.00% | 5.00% |
| Mgmnt of companies, enterprises | | | | | | | | | | | | | | |
| Administrative, support services | 1.60% | 1.00% | 4.70% | 4.70% | 4.70% | 4.70% | 1.00% | 1.00% | 2.00% | 2.00% | 2.00% | 2.00% | 2.00% | 2.00% |
| Waste mgmnt, remed services | 0.50% | 0.50% | 0.50% | 0.50% | 0.50% | 0.50% | 0.50% | 0.50% | | | | | | |
| Educational services | | | | | | | | | | | | | | |
| Ambulatory health care services | | | | | | | | | | | | | | |
| Hospitals | 0.10% | 0.10% | 0.10% | 0.10% | 0.10% | 0.10% | 0.10% | 0.10% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% |
| Nursing, residential care facilities | | | | | | | | | | | | | | |
| Social assistance | | | | | | | | | | | | | | |
| Performing arts, spectator sports | | | | | | | | | | | | | | |
| Museums et al. | | | | | | | | | | | | | | |
| Amusement, gambling, recreation | | | | | | | | | | | | | | |
| Accommodation | 0.20% | 0.20% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% |
| Food services, drinking places | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% | 1.00% |
| Repair, maintenance | | | | | | | | | | | | | | |
| Personal, laundry services | | | | | | | | | | | | | | |
| Membership assoc, organ | | | | | | | | | | | | | | |
| Private households | | | | | | | | | | | | | | |
| State Gov (tax revenues) | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% | 3.00% |
| Local Gov (tax revenues) | 2.00% | | 2.00% | | 2.00% | | 2.00% | | 2.00% | | 2.00% | | 2.00% | |
| Federal Civilian | | | | | | | | | | | | | | |
| Federal Military | | | | | | | | | | | | | | |
| Farm | | | | | | | | | | | | | | |

All figures represent the percentage of total project costs for a single project.
Instate figures are the percentage of total project costs which will be paid to instate businesses and employees

## APPENDIX D (cont.)

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### Table P - O&M Cost Fractions

| | COAL | | GAS PEAKER | | GAS COMBINED CYCLE | | WIND | | BIOMASS | | ANAEROBIC DIGESTION | | LANDFGILL GAS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | In-State | Total | In-State | Total | In-State | Total | In-State | Total | In-State | Total | In-State | Total | In-State |
| Forestry et al. | | | | | | | | | | | | | | |
| Agriculture | | | | | | | | | | | | | | |
| Oil, gas extraction | | | | | | | | | | | | | | |
| Mining (except oil, gas) | | | | | | | | | | | | | | |
| Support activities for mining | | | | | | | | | | | | | | |
| Utilities | 100.00% | 85.00% | 100.00% | 85.00% | 100.00% | 85.00% | 100.00% | 85.00% | 100.00% | 85.00% | 100.00% | 85.00% | 100.00% | 0.85 |
| Construction | | | | | | | | | | | | | | |
| Wood product mfg | | | | | | | | | | | | | | |
| Nonmetallic mineral prod mfg | | | | | | | | | | | | | | |
| Primary metal mfg | | | | | | | | | | | | | | |
| Fabricated metal prod mfg | | | | | | | | | | | | | | |
| Machinery mfg | | | | | | | | | | | | | | |
| Computer, electronic prod mfg | | | | | | | | | | | | | | |
| Electrical equip, appliance mfg | | | | | | | | | | | | | | |
| Motor vehicle mfg | | | | | | | | | | | | | | |
| Transp equip mfg. exc. motor veh | | | | | | | | | | | | | | |
| Furniture, related prod mfg | | | | | | | | | | | | | | |
| Miscellaneous mfg | | | | | | | | | | | | | | |
| Food mfg | | | | | | | | | | | | | | |
| Beverage, tobacco prod mfg | | | | | | | | | | | | | | |
| Textile mills | | | | | | | | | | | | | | |
| Textile prod mills | | | | | | | | | | | | | | |
| Apparel mfg | | | | | | | | | | | | | | |
| Leather, allied prod mfg | | | | | | | | | | | | | | |
| Paper mfg | | | | | | | | | | | | | | |
| Printing, rel supp act | | | | | | | | | | | | | | |
| Petroleum, coal prod mfg | | | | | | | | | | | | | | |
| Chemical mfg | | | | | | | | | | | | | | |
| Plastics, rubber prod mfg | | | | | | | | | | | | | | |
| Wholesale trade | | | | | | | | | | | | | | |
| Retail trade | | | | | | | | | | | | | | |
| Air transportation | | | | | | | | | | | | | | |
| Rail transportation | | | | | | | | | | | | | | |
| Water transportation | | | | | | | | | | | | | | |
| Truck transp; Couriers, msngrs | | | | | | | | | | | | | | |
| Transit, ground pass transp | | | | | | | | | | | | | | |
| Pipeline transportation | | | | | | | | | | | | | | |
| Scenic, sightseeing transp; supp | | | | | | | | | | | | | | |
| Warehousing, storage | | | | | | | | | | | | | | |
| Publishing, exc Internet | | | | | | | | | | | | | | |
| Motion picture, sound rec | | | | | | | | | | | | | | |
| Internet serv, data proc, other | | | | | | | | | | | | | | |
| Broadcasting, exc Int; Telecomm | | | | | | | | | | | | | | |
| Monetary authorities, et al. | | | | | | | | | | | | | | |
| Sec, comm contracts, inv | | | | | | | | | | | | | | |
| Ins carriers, rel act | | | | | | | | | | | | | | |
| Real estate | | | | | | | | | | | | | | |
| Rental, leasing services | | | | | | | | | | | | | | |
| Prof, tech services | | | | | | | | | | | | | | |
| Mgmnt of companies, enterprises | | | | | | | | | | | | | | |
| Administrative, support services | | | | | | | | | | | | | | |
| Waste mgmnt, remed services | | | | | | | | | | | | | | |
| Educational services | | | | | | | | | | | | | | |
| Ambulatory health care services | | | | | | | | | | | | | | |
| Hospitals | | | | | | | | | | | | | | |
| Nursing, residential care facilities | | | | | | | | | | | | | | |
| Social assistance | | | | | | | | | | | | | | |
| Performing arts, spectator sports | | | | | | | | | | | | | | |
| Museums et al. | | | | | | | | | | | | | | |
| Amusement, gambling, recreation | | | | | | | | | | | | | | |
| Accommodation | | | | | | | | | | | | | | |
| Food services, drinking places | | | | | | | | | | | | | | |
| Repair, maintenance | | | | | | | | | | | | | | |
| Personal, laundry services | | | | | | | | | | | | | | |
| Membership assoc, organ | | | | | | | | | | | | | | |
| Private households | | | | | | | | | | | | | | |
| State Gov | | | | | | | | | | | | | | |
| Local Gov | | | | | | | | | | | | | | |
| Federal Civilian | | | | | | | | | | | | | | |
| Federal Military | | | | | | | | | | | | | | |
| Farm | | | | | | | | | | | | | | |

## APPENDIX D (cont.)

### Table Q - Fuel Cost Fractions

| | COAL | | GAS PEAKER | | GAS COMBINED CYCLE | | WIND | | BIOMASS | | ANAEROBIC DIGESTION | | LANDFGILL GAS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | In-State | Total | In-State | Total | In-State | Total | In-State | Total | In-State | Total | In-State | Total | In-State |
| Forestry et al. | | | | | | | | | | | | | | |
| Agriculture | | | | | | | | | 100.00% | 100.00% | 100.00% | 100.00% | | |
| Oil, gas extraction | | | 100.00% | 0.00% | 100.00% | 0.00% | | | | | | | | |
| Mining (except oil, gas) | | | | | | | | | | | | | | |
| Support activities for mining | | | | | | | | | | | | | | |
| Utilities | 10.00% | | | | | | | | | | | | | |
| Construction | | | | | | | | | | | | | | |
| Wood product mfg | | | | | | | | | | | | | | |
| Nonmetallic mineral prod mfg | | | | | | | | | | | | | | |
| Primary metal mfg | | | | | | | | | | | | | | |
| Fabricated metal prod mfg | | | | | | | | | | | | | | |
| Machinery mfg | | | | | | | | | | | | | | |
| Computer, electronic prod mfg | | | | | | | | | | | | | | |
| Electrical equip, appliance mfg | | | | | | | | | | | | | | |
| Motor vehicle mfg | | | | | | | | | | | | | | |
| Transp equip mfg, exc. motor veh | | | | | | | | | | | | | | |
| Furniture, related prod mfg | | | | | | | | | | | | | | |
| Miscellaneous mfg | | | | | | | | | | | | | | |
| Food mfg | | | | | | | | | | | | | | |
| Beverage, tobacco prod mfg | | | | | | | | | | | | | | |
| Textile mills | | | | | | | | | | | | | | |
| Textile prod mills | | | | | | | | | | | | | | |
| Apparel mfg | | | | | | | | | | | | | | |
| Leather, allied prod mfg | | | | | | | | | | | | | | |
| Paper mfg | | | | | | | | | | | | | | |
| Printing, rel supp act | | | | | | | | | | | | | | |
| Petroleum, coal prod mfg | 50.00% | | | | | | | | | | | | | |
| Chemical mfg | | | | | | | | | | | | | | |
| Plastics, rubber prod mfg | | | | | | | | | | | | | | |
| Wholesale trade | | | | | | | | | | | | | | |
| Retail trade | | | | | | | | | | | | | | |
| Air transportation | | | | | | | | | | | | | | |
| Rail transportation | 40.00% | | | | | | | | | | | | | |
| Water transportation | | | | | | | | | | | | | | |
| Truck transp; Couriers, msngrs | | | | | | | | | | | | | | |
| Transit, ground pass transp | | | | | | | | | | | | | | |
| Pipeline transportation | | | | | | | | | | | | | | |
| Scenic, sightseeing transp; supp | | | | | | | | | | | | | | |
| Warehousing, storage | | | | | | | | | | | | | | |
| Publishing, exc Internet | | | | | | | | | | | | | | |
| Motion picture, sound rec | | | | | | | | | | | | | | |
| Internet serv, data proc, other | | | | | | | | | | | | | | |
| Broadcasting, exc Int; Telecomm | | | | | | | | | | | | | | |
| Monetary authorities, et al. | | | | | | | | | | | | | | |
| Sec, comm contracts, inv | | | | | | | | | | | | | | |
| Ins carriers, rel act | | | | | | | | | | | | | | |
| Real estate | | | | | | | | | | | | | | |
| Rental, leasing services | | | | | | | | | | | | | | |
| Prof, tech services | | | | | | | | | | | | | | |
| Mgmnt of companies, enterprises | | | | | | | | | | | | | | |
| Administrative, support services | | | | | | | | | | | | | | |
| Waste mgmnt, remed services | | | | | | | | | | | | | 100.00% | 100.00% |
| Educational services | | | | | | | | | | | | | | |
| Ambulatory health care services | | | | | | | | | | | | | | |
| Hospitals | | | | | | | | | | | | | | |
| Nursing, residential care facilities | | | | | | | | | | | | | | |
| Social assistance | | | | | | | | | | | | | | |
| Performing arts, spectator sports | | | | | | | | | | | | | | |
| Museums et al. | | | | | | | | | | | | | | |
| Amusement, gambling, recreation | | | | | | | | | | | | | | |
| Accommodation | | | | | | | | | | | | | | |
| Food services, drinking places | | | | | | | | | | | | | | |
| Repair, maintenance | | | | | | | | | | | | | | |
| Personal, laundry services | | | | | | | | | | | | | | |
| Membership assoc, organ | | | | | | | | | | | | | | |
| Private households | | | | | | | | | | | | | | |
| State Gov | | | | | | | | | | | | | | |
| Local Gov | | | | | | | | | | | | | | |
| Federal Civilian | | | | | | | | | | | | | | |
| Federal Military | | | | | | | | | | | | | | |
| Farm | | | | | | | | | | | | | | |

## APPENDIX D (cont.)

### Table R - Energy Efficiency Cost Allocation

| | TOTAL | In-State |
|---|---|---|
| Forestry et al. | | |
| Agriculture | | |
| Oil, gas extraction | | |
| Mining (except oil, gas) | | |
| Support activities for mining | | |
| Utilities | | |
| Construction | 10.00% | 10.00% |
| Wood product mfg | | |
| Nonmetallic mineral prod mfg | | |
| Primary metal mfg | | |
| Fabricated metal prod mfg | | |
| Machinery mfg | | |
| Computer, electronic prod mfg | 25.00% | 12.50% |
| Electrical equip, appliance mfg | 30.00% | 9.00% |
| Motor vehicle mfg | | |
| Transp equip mfg, exc. motor veh | | |
| Furniture, related prod mfg | | |
| Miscellaneous mfg | | |
| Food mfg | | |
| Beverage, tobacco prod mfg | | |
| Textile mills | | |
| Textile prod mills | | |
| Apparel mfg | | |
| Leather, allied prod mfg | | |
| Paper mfg | | |
| Printing, rel supp act | | |
| Petroleum, coal prod mfg | | |
| Chemical mfg | | |
| Plastics, rubber prod mfg | | |
| Wholesale trade | | |
| Retail trade | 10.00% | 10.00% |
| Air transportation | | |
| Rail transportation | | |
| Water transportation | | |
| Truck transp; Couriers, msngrs | | |
| Transit, ground pass transp | | |
| Pipeline transportation | | |
| Scenic, sightseeing transp; supp | | |
| Warehousing, storage | | |
| Publishing, exc Internet | | |
| Motion picture, sound rec | | |
| Internet serv, data proc, other | 5.00% | 5.00% |
| Broadcasting, exc Int; Telecomm | | |
| Monetary authorities, et al. | | |
| Sec, comm contracts, inv | | |
| Ins carriers, rel act | | |
| Real estate | | |
| Rental, leasing services | | |
| Prof, tech services | 10.00% | 10.00% |
| Mgmnt of companies, enterprises | | |
| Administrative, support services | 5.00% | 5.00% |
| Waste mgmnt, remed services | | |
| Educational services | | |
| Ambulatory health care services | | |
| Hospitals | | |
| Nursing, residential care facilities | | |
| Social assistance | | |
| Performing arts, spectator sports | | |
| Museums et al. | | |
| Amusement, gambling, recreation | | |
| Accommodation | | |
| Food services, drinking places | | |
| Repair, maintenance | | |
| Personal, laundry services | | |
| Membership assoc, organ | | |
| Private households | | |
| State Gov | 3.00% | 3.00% |
| Local Gov | 2.00% | |
| Federal Civilian | | |
| Federal Military | | |
| Farm | | |

# APPENDIX E – MODELING TOOLS

## 1. Energy 2020

ENERGY 2020 is an integrated multi-region energy model that provides complete and detailed, all-fuel demand and supply sector simulations. These simulations can additionally include macroeconomic interactions to determine the benefits or costs to the local economy of new facilities or changing energy prices. The model can be used in regulated as well as deregulated and transitioning environments. It portrays the interaction of market competitors in a realistic, as opposed to an idealized, fashion, including transmission-system market-dynamics. Criteria Air Contaminant and Greenhouse Gas pollution emissions and costs, including allowances and trading, are endogenously determined, thereby allowing assessment of environmental risk and co-benefit impacts. Energy2020 gas been used by numerous utilities, government, and non-governmental organizations, including the U.S. Department of Energy, Environment Canada, Western Resources, Vermont Department of Public Service, Massachusetts Department of Energy Resources, Ontario Ministry of Energy, KN Energy, Minnesota Department of Public Service, Southern California Edison, Duke Energy, US EPA, etc.

***ENERGY 2020 is a policy planning model.*** It contains hundreds of “standard” policy options and literally thousands of policy variables to create new policies. For climate change efforts some generic policy categories include tax incentives/disincentives, exogenous additions to delivered energy prices, new regulations/market structures, grants and rebates, efficiency standards, renewable energy options, consumer awareness, permit trading and consumer behaviours and their responsiveness to various options.

The model is descriptive. It simulates the physical and economic flows of energy users and suppliers. It simulates how they make decisions and how those decisions causally translate to energy-use and emissions. In ENERGY 2020, those decisions include process/shell efficiency and costs decisions, device efficiency and cost decisions, new investment market-share decisions, and utilization decisions. Weather and economic conditions affect utilization as much as the energy price conditions. The actual impacts of the climate change itself can be tested. The model accumulates both process (facility) and device capital stocks, and simulates their retirements. It calculates both the marginal and average costs and efficiencies. Process efficiency (how much energy service the household or factory needs to produce its output) determines the amount of energy that must come out of the devices (furnaces, hot water heaters, refrigerators, lights, etc.). The device efficiency deters the amount of fuel which the device must burn to produce the energy service required. In space heating, for example, the efficiency of the building shell is the process efficiency and determines how much energy must be produced by the furnace. The furnace efficiency is the device efficiency and determines how much natural gas must be burned to produce the heat needed to warm the house.

All demands are “derived.” Energy services are needed to produce output. Energy is not a need unto itself. Even transportation is a derived need. The model provides transportation services. The device is the mode used to serve that need. The transportation demands are split into passenger, freight, and off-road. Rail for industry ships freight. Rail for residential transports commuters. The process efficiency determines how much transportation is needed. The model captures the movement of commuters to live near employment or industry to manufacture near demand. Part of the (endogenous) process efficiency also determines whether people take a bicycle, auto, or rapid transit.

**APPENDIX E (cont.)**

The economic sectors can be added, but the current configuration includes up to three classes of residential, 14 classes of commercial and in the industrial sector 24 manufacturing industries and 10 mining categories plus construction, agriculture and forestry. Each class has 6 to 8 end-uses (process heat, space heat, cooling, lighting, cooking, etc.)
Process costs (endogenously based on energy decisions) and device costs (the marginal costs of using energy from the device) determine the energy choices. These choices maximize the utility of using the energy as determined with the Qualitative Choice Theory (QCT). One important aspect of QCT is that it considers both price and preferences. It includes the extent to which market participants know of or have access to the choice. For example, some people only want large safe cars and efficiency is secondary. Some people live in rural areas and do not have access to natural gas. There may be a new heat pump technology that works well in northern climates but if it is not fully marketed/advertised, few know to select it. All the decisions (their components and information flows) that are relevant to consumer energy choice are endogenously simulated.

Additionally each demand sector, including transportation, has a self-generation sub-sector. These sectors can simulate cogeneration and distributed generation including fuel cells and micro-turbines. Lastly, each demand sector includes a demand for energy feedstocks (solvents, reactants, lubricants, asphalt, etc.)

For the electricity supply sector, each major department and business unit is fully simulated. The model endogenously determines regulatory rate-making or deregulation market-price setting depending on the regulatory regime. Generation is detailed by plant type for each energy supplier. Unit level simulation can be provided but are longer and more expensive. Centralized or decentralized dispatch -- with full accounting of transmission constraints are provided. Demand and supply "occupy" transmission "nodes" and prices can be by node. The end-use demands (for each industry and consumer class) are used to build up seasonal load duration curves. Representative hours from those curves are "dispatched" and integrated to produce season supply and primary energy demands for the utilities. The end-use aspect of the load captured noticeable changes in electric utility operations due to climate change policies that affect one end-use (or industry) more than other. The electric system is simulated as the inter-provincial/international network it actually is. Thus, all trade is accurately and dynamically captured.

The electricity sector simulates new market entrants, deregulation, capacity expansion, mergers and acquisitions, and bankruptcies. Independent power producers (IPPs) and third-party-owned distributed generation are treated as distinct companies. Utility decision making practices are estimated historically. Options allow alternative or mandated rules on new plants or additions. Renewable, as well as, conventional electric generation technologies are simulated.

Refining, primary oil production, primary gas production, coal production, and ethanol production are represented with comparable detail. The existing oil, gas, and coal sectors will determine production based on demand and losses (plus own use of fuels.) Specific production potentials for conventional on-shore and offshore oil and gas are from national sources. The utilization of other technologies (heavy oil, SynCrude, Bitumen, etc.) are then a function of additional demand. The market share (using QCT) can also be a function own-costs. Comparing world crude oil prices to domestic costs, determines total domestic production and, consequently, also net imports. Coal technologies are not explicitly simulated but losses and producer fuel use

**APPENDIX E (cont.)**

are. For all fuels, primary energy prices are converted to delivered product prices at each province or state by considering delivery/conversion costs and any applicable taxes. Ethanol production is currently a simple representation of the expansion of capacity based on the demand for ethanol. The sector tracks ethanol production, capacity, costs, producer consumption, and emissions.

For energy related pollution, ENERGY 2020 can keep track of the marginal pollution potential of each new consumer and energy suppler investment. These margin changes flow into a stock of embodied pollution that is used to determine the existing emission potential associated with utilizing existing energy-using capital stocks. The pollution is removed with capital stock retirements or retrofitting. The actual pollution is the average pollution potential per unit of output times the actual amount of output (utilization) of the stock. This stock represents the cars, furnaces, power plants, etc. in the economy. Stocks and pollution are calculated by end-use (or plant type or mode), technology family, economics sector, and province.

Additionally, the pollution sectors simulate all forms of allowance trading and auctions. Trading can occur only within single provinces and within single economic sectors. The logic can expand out to include just national industrial or utility sectors. All possibilities out to all-sectors with international trading can be simulated. Because the simulation is behavioural, sometimes market participants under or over estimate their allowance needs and emissions transiently stray above or below goals. The market model iterates on price as based on the balance (or imbalance) of supply and demand. As with any other commodity, the price of allowances is volatile. Some market actors get in positions where they temporarily cannot reduce emissions adequately. Investments take time to produce results. Limited information can further distort the investment process.

ENERGY 2020 has three non-energy emission categories. The simplest category is the feedstocks. Feedstocks are requirements of producing output (just like all energy.) It is a simple function of economic output. A fraction of feedstocks is assumed lost to the environment via burning or natural decomposition. Next are emissions from economic activity and industrial processes such as cement, magnesium, aluminium and nylon manufacture, to name a few. Again, these are functions of economic output. Changes in process functions to reduce these emissions per unit of output as a function of price are determined using marginal abatement cost curves. Last are reversible emissions from crops, forests, and municipal waste. Crops take in $CO_2$ as they grow. They expel $CO_2$ and $CH_4$ as the biomass decays. Crop production can be a net emitter or sink depending on conditions. (Emissions from fertilizer use fall under the category of economic activity emissions.)

ENERGY 2020 uses a stock-and-flow representation to capture both the absorption and decay of biomass. The stock is the sequestered $CO_2$. Similarly, trees absorb $CO_2$ as they grow. As a forest matures, the intake is less. As trees die they decay and release emissions. ENERGY 2020 uses a renewable resource regeneration simulation to capture the growth and decay patterns of trees. Losses to paper and lumber are included. Lumber becomes a long lifetime sequestering of $CO_2$. Paper produces a shorter life sequestering (Emissions from paper production are determined in the paper industry sector). Municipal solid waste sequesters some biomass but after a time, the decomposition produces $CO_2$ and methane. Like the crop sector, stocks and flows are used to capture the dynamics and the impacts of policy options.

**APPENDIX E (cont.)**

# 2. REMI Policy Insights

The Regional Economic Models, Inc. (REMI) Policy Insight model is a general equilibrium model designed to give policy-makers information on the potential economic impacts of various government activities. The model can cover the entire nation, individual states, groups of states, and sub-state regions (i.e. counties and large cities). The particular version that we used treats the state of Michigan as one region. Use of the model for policy analysis follows these four steps:

1. Formulate a policy question.
2. Generate a baseline forecast.
3. Generate an alternative forecast with affected policy variables.
4. Compare the 2 forecasts.

The baseline forecast is created by running a "Control" analysis with the model. The user then runs a policy simulation that uses our specific control as the baseline forecast and compares this to the model output that results from changing policy variables. The output can be displayed as a final level, an absolute change, or a percentage change. For instance, we can show that a policy will result in a total employment level in Michigan of 5,100,000 people, an increase of 100,000, or an increase of 2%. The values are calculated on an annual basis over a user-defined time period, with the model forecasting through the year 2050.

While the model gives a large amount of data as output, the most commonly used output variables are changes in the state employment and gross product. The primary challenge for the user is to translate various strategies into policy input variables that can be entered into the REMI Policy Insight framework. As such, an introduction to the available input variables is useful.

## *2.1 Input Variables*

The input variables for the model fall into the following six categories, with a brief description of each:

1) **Output Block** - The Output Block linkages in the model determine local demand for components of personal consumption which depends on real income, for investment demand which depends on relative factor prices and anticipated economic activity, and for government demand which is influenced by the size of the local population. These demands are translated into industry demand which also depends on the interstate and international exports.

2) **Labor and Capital Demand Block** - The Labor and Capital Demand Block is affected by local Output. However, labor and capital utilization is also determined by Labor Productivity. This in turn depends, in part, on the relative costs of all of the factors of production.

**APPENDIX E (cont.)**

3) **Population and Labor Supply Block** - The Population and Labor Supply Block includes policy variables that directly affect Migration, Participation Rates, Special Populations, Birth and Survival Rates, and Occupational Supply.

4) **Wage, Price, and Profit Block** - The Wage, Price, and Profit Block includes policy variables that directly affect wage rates, the cost of doing business, fuel costs, consumer, housing and land prices, as well as industry prices.

5) **Market Shares Block** - The Market Shares Block includes policy variables that directly affect industries' shares of local and export markets. The share of local markets can be increased by increasing the Regional Purchase Coefficients, which represent the proportion of local demand that is supplied locally. The proportion of national and international markets can be changed using the Export Market Share and Import Market Share variables. These shares can be changed for individual industries or for the entire set of private industries at once.

6) **Fiscal Calibration Block** - The Fiscal Calibration Category includes policy variables that can adjust state and local government revenue and expenditures. The model incorporates the most recent Census of Governments data to obtain the revenue and expenditure amounts for every state government and for the county governments using state averages. Government tax and revenue policy changes must be input as policy variables in the first five blocks.

Within each of these blocks are a number of sub-categories, with these sub-categories further divided into the policy variables. Specific policy variables can be defined in several different ways. Before describing the policy variables, the different ways of defining them should be established. The primary ways are by sector and by share or amount.

## *2.2 Definition by Sector (Sect)*

The REMI model divides the state of Michigan's economy into 66 different sectors. For some variables, it is possible to define the variable for each sector individually. For example, one may want to know what the effect would be of increasing the price of electricity for vehicle manufacturing by 10%. The 62 sectors are listed in Table S, below.

**APPENDIX E (cont.)**

**Table S - REMI Economic Sectors**

| Forestry | Agriculture | Oil/gas extraction | Mining (except oil/gas) |
|---|---|---|---|
| Support activities for mining | Utilities | Construction | Wood product manufacturing |
| Nonmetallic mineral production manufacturing | Primary metal manufacturing | Fabricated metal product manufacturing | Machinery manufacturing |
| Computer/electronic product manufacturing | Electrical equipment/appliance manufacturing | Motor Vehicle manufacturing | Transportation equipment (excluding motor vehicle.) |
| Furniture/related product manufacturing | Miscellaneous manufacturing | Food manufacturing | Beverage/tobacco products manufacturing |
| Textile mills | Textile product manufacturing | Apparel manufacturing | Leather/Allied product manufacturing |
| Paper manufacturing | Printing/Related support activity | Petroleum/coal product manufacturing | Chemical manufacturing |
| Plastics/rubber manufacturing | Wholesale trade | Retail trade | Air transportation |
| Rail transportation | Water transportation | Truck transportation/ couriers/ messengers | Transit/ground passenger transportation |
| Pipeline transport | Scenic/ sightseeing transportation/ supply | Warehousing/ storage | Publishing (excluding internet) |
| Motion picture/sound recording | Internet service/data processing | Broadcasting (excluding internet)/ telecomm | Monetary authority |
| Security/communication/ contracts | Insurance carriers | Real estate | Rental/leasing services |
| Professional/technical services | Management of Companies/ Enterprises | Admin/support services | Waste management/ remediation |
| Educational services | Ambulatory health care services | Hospitals | Nursing/ Residential care facilities |
| Social assistance | Performing arts/spectator sports | Museums | Amusement/gambling/ recreation |
| Accommodations | Food services/drinking places | Repair/ Maintenance | Personal/laundry services |
| Membership associations/organizations | Private households | | |

## *2.3 Definition by Industrial or Commercial Enterprises (I/C)*

Instead of dividing the economy into the 62 sectors listed above, some variables only make the distinction between industrial and commercial enterprises.

## *2.4 Consumer Spending (CS)*

Consumer spending options are listed in Table T below.

**Table T - REMI Consumer Spending Options**

| | | |
|---|---|---|
| Vehicles and Parts | Computers and Furniture | Other Durables |
| Food and Beverages | Clothing and Shoes | Gasoline and Oil |
| Fuel Oil and Coal | Other Non-durables | Housing |
| Household Operation | Transportation | Medical Care |
| Other Services | | |

**APPENDIX E (cont.)**

## *2.5 Variable Input Methods*

Most variables allow the modeler to express the policy in either a change in the share (percentage), the amount (absolute value), or both. This is true when the variable applies to a single sector or to the whole economy. For example, one could express the variable as an increase in the price of electricity of 10% or the equivalent dollar amount, and this can be applied to an individual sector or to the entire state.